

SECTION 800 -- TRAFFIC CONTROL DEVICES AND LIGHTING

SECTION 801 -- TRAFFIC CONTROLS FOR CONSTRUCTION AND MAINTENANCE OPERATIONS

801.01 Description. This work shall consist of furnishing, placing, and maintaining signs, barricades, temporary pavement markings, temporary HMA dividers, and other traffic control devices at construction and maintenance operations in accordance with 105.03.

MATERIALS

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801.02 Materials. Materials shall be in accordance with the following:

	Bolts, Nuts, and Washers for U-Channel Steel Posts	910.02(f)
	Construction Warning Lights	913.12
	Delineator Posts	910.15
	Delineators	913.08
	Flashing Arrow Sign	913.13
	Flexible Channelizer and Flexible Tubular Marker.....	913.07.1
	Flexible Delineator Posts	913.07
20	Flexible Roll-Up Prismatic Reflective Sign.....	913.10(c)
	Glass Beads	913.09
	Highway Illumination Materials	913.11
	Primer for Field Paint.....	909.04(a)
	Prismatic Reflectors	913.14(d)1a
	Reflective Sheeting	913.10(d)
	Steel, Flanged, Channel Posts	910.14(a)
	Temporary Pavement Marking Tape	913.14(c)
	Temporary Raised Pavement Markers.....	913.14(d)2
	Thermoplastic.....	913.14(b)1
30	Traffic Signal Materials and Equipment.....	913.15
	Traffic Signs	913.10
	White and Yellow Traffic Paint	909.05
	White Field Paint, Finish Coat.....	909.04(b)
	Wood Sign Posts	911.02(e)

801.02.1 General Requirements. The applicable requirements of the MUTCD shall apply to the installation and materials for traffic control devices subject to the requirements of 107.08 and 107.12.

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Temporary traffic control devices shall be maintained continuously, except as described herein, to ensure visibility and to protect the public. All reflective sheeting backgrounds and lights shall be kept clean of foreign matter.

All barricades, signs, or flashing arrow signs shall be moved from one location and re-erected at another location as shown on the plans or as directed.

Temporary drainage structures, temporary concrete median barrier units, and other temporary devices required and used for traffic maintenance shall remain the property of the Contractor.

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CONSTRUCTION REQUIREMENTS

801.03 Construction Signs. Construction signs shall be those detailed on the plans or as set out in the MUTCD. The item includes the typical sign standard or posts which support the sign, all necessary hardware, and specified construction warning lights. The size and number of posts used for construction signs shall be as shown on the plans. Metal posts shall be in accordance with 910.14(a). However, they may be painted in lieu of galvanization. Wood posts shall be in accordance with 911.02(e). Construction sign type A shall consist of a construction sign as detailed in the MUTCD or on the Standard Drawings which is 0.84 m² (9 sq ft) or more in area. Construction sign type B shall consist of a construction sign as detailed in the MUTCD or on the Standard Drawings, which is less than 0.84 m² (9 sq ft) in area. Construction sign type C shall consist of a construction sign which is not detailed in the MUTCD or on the Standard Drawings, which is 0.84 m² (9 sq ft) or more in area. Construction sign type D shall consist of a construction sign which is not detailed in the MUTCD or on the Standard Drawings, which is less than 0.84 m² (9 sq ft) in area. The background of construction signs shall be reflective sheeting as specified on the plans. Flexible roll-up signs may be used in maintenance and utility work of short duration only. The flexible roll-up signs shall not be used within the limits of an active contract unless otherwise specified.

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Signs required for use with standard barricades shall be supported on the typical sign standard as shown on the plans. Portable construction signs may be supported on the typical sign standard. The typical sign standard wood posts and support members shall be painted with primer and white field paint.

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A route or lane closure notice sign shall consist of a construction sign type A which indicates route or lane closure. The sign copy shall be as directed. The top line of copy shall describe the closed facility, such as route number, exit ramp, or which lane. The bottom line of copy shall state the closure date. All copy shall be symmetrical about the longitudinal sign centerline. The sign shall be mounted for a maximum of 14 calendar days and a minimum of seven calendar days before the closure date shown on the sign. The sign shall be mounted on two type B posts or two 100 mm by 100 mm (4 in. by 4 in.) wood posts. Horizontal and vertical sign clearances shall be as shown on the plans. The sign shall be removed when directed.

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Small, lightweight trailers may be used as supports for portable construction signs. The trailer, not including the sign and warning light, shall weigh no more than 140 kg (300 lb) and shall not be fabricated with heavier than 76 mm by 76 mm (3 in. by 3 in. angles), 63 mm (2 1/2 in. pipe), or 76 mm by 51 mm (3 in. by 2 in.) rectangular tubing. The rim size of the wheels shall not exceed 310 mm (12 in.). Axle assemblies with differential housings shall not be used. The trailer shall be located and constructed to hold the sign in a proper position as shown on the plans. The position of the tongue shall be so as to cause no hazard to traffic. Wheel chocks other than sandbags shall not be used. The tongue may be pinned to reduce wind induced rolling if designed to pull up or

break from vehicle impact. The method of pinning will require approval. During nonworking hours, trailers with signs that do not apply to existing conditions shall be stored in accordance with 107.07.

100 Sign posts and their foundations shall be located and constructed to hold signs in a proper position; to resist swaying, turning, or displacement; and at the same time constitute the least possible hazard to motorists. No rigidly fixed sign supports will be permitted in exposed areas where it would be practicable to utilize a breakaway or yielding type design. Signs shall be completely covered or removed when it is determined that the message does not apply. Signs supported on tripod supports will be permitted only when the allowable vertical mounting height to the bottom of the sign is 460 mm (18 in.) or less. When permitted for use, the signs supported on tripod supports shall be installed so that the angle from vertical does not exceed 30 degrees.

110 No regulatory controls shall be erected until approved by the agency having jurisdiction. Advisory speeds to be posted will be determined by the Engineer.

If the work on a project, or a portion thereof, is not in an active state, a written request to remove construction warning signs is made, and the Engineer determines the roadway is open to unrestricted traffic, such construction warning signs may be removed until work resumes. Removal of such signs shall not relieve the Contractor of responsibilities or liabilities described elsewhere herein.

120 **801.04 Temporary Worksite Speed Limit Sign Assemblies.** This work shall consist of furnishing and placing portable speed limit signs as directed in areas where the work activity is determined to constitute a hazard to or because of traffic, especially where lane closures are required. These sign assemblies may be installed on frangible posts or mounted on movable stands or trailers.

Indiana law provides for establishment of enforceable reduced speed limits in worksites without the Official Action process normally associated with speed zone establishment. The law also establishes the parameters for the worksite speed zone.

130 If specified, the temporary worksite speed limit will be required on all Interstate and 4-lane roadways where traffic is restricted and work is in progress.

The worksite speed zone signage shall be installed and maintained by the Contractor. The worksite speed limit will be 70 km/h (45 mph), or 15 km/h (10 mph) below the established speed limit for the roadway under construction, whichever is lower. The worksite speed limit shall be in effect only where and while work is actually in progress, and workers are present.

140 All worksite speed limit sign assemblies shall have a plaque which reads "Worksite" above the regulatory sign. Worksite speed limit signs shall be placed on both sides of each set of lanes on dual lane roadways. The worksite speed limit signs shall be of the speed limit sign size specified for freeways in the MUTCD. The longitudinal spacing between worksite speed limit signs shall be no greater than 3.2 km (2 mi). Closer spacing may be directed to adequately address conditions for a specific project. In rural

areas, a worksite "Reduced Speed Ahead" sign shall be placed in advance of the beginning of a worksite speed limit.

150 The assembly signs shall be in accordance with the MUTCD. The signs shall be installed on frangible posts or mounted on movable stands or trailers in accordance with 801.03. The minimum horizontal clearance for the signs shall be as shown on the plans or as directed. The minimum vertical clearance shall be such that the bottom of the speed limits sign is 5.0 feet (1.5 m) above the edge of the traveled roadway, unless otherwise shown on the plans. The installed or portable signs shall incorporate strobe type flashing lights mounted at the same level, one on each side of the speed limit sign in the upper quarter of the speed limit sign. Such strobe lights shall feature monodirectional yellow or amber lenses with reflectors. The lights shall be visible through a range of 120 degrees when viewed facing the sign. Each strobe light shall have a minimum effective luminance of 2100 candela effective. The lights shall have a minimum flash rate of 30 per min and a maximum flash rate of 120 per min. The strobe lights shall operate on either full battery power with solar panel charging and 135 amperes, 12 volts deep cycle batteries, or a diesel powered generator with a maximum fuel capacity of 95 L (25 gal.). The tops of batteries used for installed signs shall not exceed 460 mm (18 in.) above the ground level. The solar panel charging shall be capable of maintaining a charged battery level. A photo-controlled transfer relay for automatic lamp intensity may be used. During nighttime operation, the lowest photo control setting shall not be less than 50% of full intensity.

Materials furnished under this specification shall be covered by a certification in accordance with 916.02(d).

170 A plaque which reads "When Flashing" shall be installed below the speed limit sign. The plaque shall be mounted such that its bottom is 1.2 m (4 ft) above the edge of the traveled roadway, unless otherwise shown on the plans. The speed limit sign shall be mounted above the plaque or at a distance of 90 km/h (5 ft) above the edge of the traveled roadway, whichever is higher. The flashing lights shall be activated when the worksite speed limit is in effect. An on/off switch will also be required.

180 The worksite speed limit shall not be used for the entire length of a roadway under construction unless there is actual work activity for the entire length of such roadway. It shall not be set up at the beginning of the day, for the entire day, if actual work is not being done all day in the work area. The worksite speed zone will begin at the first installed sign assembly before the work location and will end after the worksite. The sequence and spacing of signs for a dual-lane worksite with an established speed limit of 90 km/h (55 mph) or greater shall be as follows:

SIGN OR ASSEMBLY

LOCATION

"Worksite"
"Reduced Speed 70 km/h Ahead"
("Reduced Speed 45 mph Ahead")
Double Installation

910 m (3000 ft) ± from
beginning of worksite taper

190	"Worksite" "Speed Limit 70 km/h" ("Speed Limit 45") "When Flashing" Double Installation	460 m (1500 ft) ± from beginning of worksite taper
200	"Worksite" "Speed Limit 70 km/h" ("Speed Limit 45") "When Flashing" Double Installation	150 m (500 ft) beyond an inter- change's last entrance ramp or at intervals of 3.2 km (2 mi) throughout the worksite if the worksite is 3.2 km (2 mi) or longer

801.05 Detour Route Marker Assembly. Detour route marker assemblies shall be as shown on the plans or as directed. The detour route marker assembly shall include the detour marker, specified route marker or street or road sign, cardinal directional marker when specified, directional arrow marker, posts which support the assembly, and all necessary hardware.

210 Detour route marker assemblies shall be placed at locations shown on the plans. The detour route marker assemblies shall be removed when directed and shall remain the property of the Contractor.

801.05.1 Road Closure Sign Assembly. Road closure sign assemblies shall be as shown on the plans. Such assemblies shall be used at each road closure location where type III-A barricades or type III-B barricades are used. Such barricades shall be in accordance with 801.07. Road closure sign assemblies shall not be used at lane closures where adjacent lanes remain open to traffic, unless otherwise directed. Road closure sign assemblies may be required at other locations as directed.

220 **801.06 Vehicle Warning Lights.** All Contractor's vehicles and motorized equipment, except as set out in 107.11, working under traffic outside of a barricaded or channelized work area, on the traveled roadway or on the shoulder shall display an operating amber light visible to all approaching traffic for a distance of 300 m (1,000 ft). The light shall be an amber strobe light or an amber flashing, oscillating or rotating incandescent, directed beam light. The amber light shall be displayed by all vehicles and motorized equipment used to install, remove, maintain, or repair traffic control devices, including signs, signals, pavement marking and lighting.

230 **801.07 Barricades.** Barricades shall be as shown on the plans. They shall include rails, posts, signs, sign standards, sign supports, lights, and all incidentals necessary to complete this part of the work.

Manufactured hi-intensity reflective sheeting with orange and white diagonal strips or orange encapsulated lens reflective sheeting background with strips of white enclosed lens or white encapsulated lens reflective sheeting shall be placed on specified rails of all barricades.

240 The American Traffic Safety Services Association, Inc. brochure titled Quality Standards For Work Zone Traffic Control Devices is incorporated into the contract by reference. Such brochure will be used as a guide to determine if traffic control devices are Acceptable, Marginal, or Unacceptable as defined in the brochure. A copy of the brochure will be made available for the Contractor to review prior to initial setup of traffic control devices.

The width, spacing, and direction of stripes shall be as shown on the plans. All wood posts and support members shall be painted with primer and white field paint.

250 Construction signs shall not be mounted drums. Construction warning lights shall be furnished in accordance with 801.11. Barricades shall be stabilized only as shown on the plans.

Types of barricades shall be as shown on the plans and as set out below.

(a) **Type III-A Barricade.** A type III-A barricade shall consist of a composite barricade unit made up of sections of triple rails which are skid mounted, and sections of rail which are on ground mounted posts. The type III-A barricade shall have reflectorized rails on one side. Type III-A barricades shall be used on all slopes which are 3:1 or flatter for roadway closures shown on the plans or as directed.

260 That portion of a type III-A barricade which is located within the pavement and shoulder area shall be mounted on skid type supports as shown on the plans. That portion of a type III-A barricade which is located on the roadside area outside the pavement and shoulder area shall be ground mounted as shown on the plans.

(b) **Permanent Type III-A Barricade.** Permanent type III-A barricades shall be used at the locations shown on the plans. Such barricades shall be left in place after the contract is completed, and shall become the property of the Department. Such barricades shall otherwise be in accordance with 801.07(a).

270 (c) **Type III-B Barricade.** Type III-B barricades shall be in accordance with 801.07(a) except the type III-B barricade shall have reflectorized rails on both sides. Such barricades shall be used for roadway closures and lane closures as shown on the plans.

280 **801.08 Cones, Flexible Channelizers, and Tubular Markers.** Cones shall be made of rubber or other material to withstand impact without damage to themselves or to striking vehicles. They shall have a substantial base to restrict overturning. Orange shall be the predominant color. The base may be black. Cones shall be used only during temporary activities where portability is advantageous and only where there is sufficient supervision to see that they remain in place and do not create a hazard to traffic. Cones shall be used to keep vehicles from running over newly installed snowplowable raised pavement marker castings until the adhesive is tack free. The use of cones in lieu of drums will be permitted during daylight hours unless otherwise directed.

Flexible channelizers and tubular markers shall be used in combination for separating two-lane two-way traffic as shown on the plans where directed. Flexible

channelizers or tubular markers shall be reflectorized with flexible encapsulated lens reflective sheeting. "No Left Turn" "Into Driveways" construction sign assemblies shall be placed as shown on the plans.

290 Minimum dimensions and reflectorization pattern of cones, flexible channelizers, and tubular markers shall be as shown on the plans. They shall be secured in place either by weighting or adhesives so as not to be displaced by passing traffic. The use of metal bases will not be permitted.

801.09 Temporary HMA Divider. Temporary HMA divider shall be placed in accordance with 605.07. Tubular markers in accordance with 801.08 shall be placed along the centerline of the HMA divider and shall be secured in place with adhesives.

300 The temporary HMA divider shall be painted with yellow traffic paint in accordance with 808.06(a).

801.10 Drums. Drums shall be used for traffic warning or channelization in the work zone area. Drums shall be molded orange polyethylene. The pigment shall be stabilized against fading caused by ultraviolet or other light. The drum shall not crack or crease from repeated vehicle impacts at temperatures from -30°C (-20°F) through 50°C (120°F). The drums shall be in acceptable condition, without cracking or creasing, at all times when in use. Permanently distorted drums shall not be used.

310 The shape of the drum shall appear basically cylindrical to the motorist from any direction in any given application. The top outside diameter shall not exceed the bottom outside diameter. The drum may be slightly conical to facilitate stacking at least four high, and may be multisided, elliptical or have a flattened side to inhibit rolling.

The dimensions of the drum shall be in accordance with the plans. The minimum drum height is exclusive of any lifting handles or construction warning light mounting brackets.

320 The top section of the drum shall have at least one construction warning light mounting bracket. Construction warning light mounting brackets shall be designed to maintain the mounted construction warning lights through repeated vehicle impacts at temperatures from -30°C (-20°F) through 50°C (120°F). A handle, of sufficient strength to lift the entire drum, shall also be molded into the top section.

The drums shall be resistant to wind speeds of up to 80 km/h (50 mph) and to wind gusts created by traffic. The drums shall be stable against overturning.

330 Drums shall stand on end and shall be internally or externally ballasted. Internal ballast shall be sandbags, a molded plastic base filled with sand and closed by a locking cover, or a solid rubber base. The weight of the internal ballast shall not exceed 25 kg (55 lb) nor be less than 20 kg (45 lb). The volume of ballast shall not exceed 1/4 the drum volume. The internal ballast shall be placed in the lower 1/4 of the drum.

When a rubber tire base collar is used for external ballast, two tire base collars shall be used. The tire base collar shall have a circumferential contact with the road surface. The total mass (weight) of a two tire base collar shall not exceed 25 kg (55 lb) nor be less than 20 kg (45 lb). The maximum diameter of the tire base collar shall not exceed 940 mm (37 in.). The height of two tire base collars at the outside edge shall not exceed 125 mm (5 in.). The rubber ballasting collars shall be clean cut, proper in size, black in color, and not curved up at the edges. The interior and exterior circumference of the collar shall not be slit or cut.

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Upon impact by a vehicle traveling at a speed of 90 km/h (55 mph), the drum and ballast device shall be of a type that permits the body of the drum to separate from the base, thus allowing vehicles to easily pass over the base. The top of the drum shall be free from any openings which would allow free water to enter the ballast storage compartment of the drum. The ballast device storage compartment shall be self draining.

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The drum reflectorization colors and pattern shall be as shown on the plans. Flexible encapsulated lens reflective sheeting shall be used. The maximum distance between the edges of adjacent reflective strips shall be 50 mm (2 in.). Construction warning lights shall be used in accordance with 801.12 and shall be securely fastened to the mounting brackets. Signs shall not be mounted on drums.

Drums which are external collar ballasted shall not be used in situations where the width of the collar interferes with proper placement of the drum.

There shall be no mixing of internally ballasted or externally collar ballasted drums in each continuous set-up.

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801.11 Temporary Illumination. The temporary highway illumination shown on the plans shall be furnished, installed, and maintained in accordance with applicable requirements of 807.

All arrangements shall be made with the local electric utility company for the securing of, and paying for, all permits necessary to furnish electric power. In lieu of electric power, a portable generator may be furnished capable of furnishing sufficient power to supply all luminaires at each location on a continuous basis. However, if a portable generator is used, a watcher shall be on duty at all times to maintain the generator in an operating condition.

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The lighting shall be maintained in operation during the hours of darkness between 1/2 h after sunset and 1/2 h before sunrise and when conditions exist which tend to obscure vision.

At completion of the contract work, the temporary illumination shall be removed and shall remain the property of the Contractor. After removal of the poles, the holes shall be backfilled with B borrow.

801.12 Construction Warning Lights. These are portable, lens directed, enclosed lights. The color of the light emitted shall be yellow. All warning lights shall be

380 mounted a minimum of 910 mm (36 in.) above the traveled way to the bottom of the lens, unless conditions necessitate otherwise. Lights not working shall be repaired or replaced immediately. For each day that more than 5% of the required warning lights are not operating, a sum equal to \$4.00 per non-working light will be deducted from the monies due the Contractor.

Low intensity construction warning lights, Type A and Type C, shall be maintained so that they are visible on a clear night from a distance of 910 m (3,000 ft) when there is no external illumination directly on or in the immediate vicinity of the light. High intensity construction warning lights, Type B, shall be maintained so that they are visible from a
390 distance of 300 m (1,000 ft) on a sunny day when viewed without the sun directly on or behind the light.

(a) **Type A.** These are low intensity flashing warning lights which shall be mounted on drums, vertical panels, or on specified construction warning signs; however, traffic control devices used for maintaining traffic during unobscured daylight hours only will not require type A low intensity flashing warning lights. They are intended to warn the driver that he is proceeding through a hazardous area. These warning lights shall operate from dusk to dawn or when conditions exist which tend to obscure vision.

400 (b) **Type B.** These are high intensity, flashing, warning lights, which shall be mounted on all type III barricades closing driving lanes, and shall be mounted on all signs positioned on the pavement or obstructing a driving lane.

(c) **Type C.** These are steady burning warning lights which shall be used on drums as specified below. Drums shall be used on tapers, crossovers, lane changes, and abrupt changes in the line or direction of vehicular travel. These lights will not be required on tangent or curve sections to delineate the edge of the traveled way.

410 Type C construction warning lights shall be operated from sunset to sunrise and when conditions exist which tend to obscure vision.

801.13 Flashing Arrow Sign. Where specified, a flashing arrow sign shall be furnished, installed, and maintained in accordance with 913.13. It shall be operated continuously, when necessary, to divert traffic.

801.14 Temporary Pavement Marking. Temporary pavement markings shall be placed and maintained where shown on the plans or as directed. The markings shall consist of painted lines, temporary pavement marking tape, or temporary raised pavement markers.

420 Temporary pavement markings shall be placed in the standard pavement marking pattern in accordance with 808.04. The only exception is the dashed line pattern used on road resurface work, which shall be 1.2 m (4 ft) line segments with 11 m (36 ft) gaps. Where temporary pavement markings are to be placed on a pavement which has existing lines or markings, the incorrect lines or markings shall be removed in accordance with 808.09.

If the temporary pavement markings on road resurfacing work are to be in service from December 1 through the following March 31, such markings shall be placed in the standard pavement marking pattern. Such markings shall include lane lines, center lines, edge lines, and no-passing lines as required. Such pattern shall be applied prior to the suspension of the work, or within seven work days after the Contractor is directed to place the markings. Such markings may be painted lines, and shall be in accordance with the final markings pattern. However, only the outline of gore areas will be required.

The prismatic reflectors shall be removed from those snowplowable raised pavement markers which conflict with the proposed temporary traffic marking pattern. Removal of the reflectors shall be accomplished with a chisel or other approved method and without damaging the casting. All remaining adhesive shall be removed by sandblasting, wire brushing, or other approved method. All snowplowable raised pavement markers that are damaged by the removal of the reflector shall be replaced in accordance with 808.10 with no additional payment. When the traffic marking pattern is returned to the original pattern, prismatic reflectors shall be mounted on these existing castings in accordance with 913.14(d)1a. The removed prismatic reflectors may be reused if approved and undamaged. The color of these reflectors shall be as specified or directed.

The temporary pavement markings, after placement, shall be maintained and replaced with no additional payment. Such maintenance shall continue until the temporary pavement markings are covered with the next overlay course or are removed because they are no longer applicable.

The temporary pavement markings shall be removed immediately with no additional payment, when no longer needed for traffic control, when the temporary pavement markings will be in conflict with the succeeding traffic pattern, or when the permanent pavement markings are placed under the contract. When removing temporary pavement markings, all damage to the pavement surface shall be corrected prior to placing the final markings.

(a) Types of Temporary Pavement Markings.

1. Painted Lines. Painted lines shall be in accordance with 808 where specified or permitted. Painted lines on new HMA courses shall require a second application of paint with no additional payment. This second application shall be made as soon as practical after the first application is dry.

2. Temporary Pavement Marking Tape. Temporary pavement marking tape shall be applied to clean dry pavement in accordance with the manufacturer's recommendations or other approved method. If the tape is to be applied at a pavement temperature below 5°C (40°F), a primer may be used if recommended by the manufacturer. During the placement, temporary marking tape shall be pressed down with a rubber tire which exerts a minimum of 91 kg (200 lb) per tire. Temporary marking tape shall be new material. Its re-use will not be permitted. Temporary pavement marking tape shall be type I or type II.

a. **Type I.** Type I tape may be used for pavement markings for lane lines, center lines, and no-passing lines, which are placed parallel to the normal pavement marking pattern; however, it shall be used for these lines when they are placed on the traveled portion of the pavement at an angle to the normal pavement marking pattern.

480 Type I temporary pavement marking tape shall be removable from asphalt and concrete pavement intact or in large sections by following the manufacturer's instructions. It shall be removable either manually or with a roll-up device at pavement temperatures above 5°C (40°F) without the use of solvents, grinding or abrasive blasting. Type I temporary marking tape shall not leave a permanent visible adhesive residue on the pavement surface when it is removed. Any visible adhesive residue shall be removable without use of solvents or grinding.

490 b. **Type II.** Type II tape shall be used for pavement markings on pavement to be removed or which will be covered by additional overlay courses. Type II tape shall be used for edge lines, lane lines, and center lines which are parallel to the normal pavement markings. Type II tape may be used for lane lines or center lines on resurfacing overlay courses.

Type II temporary pavement marking tape is not readily removable. If it is necessary to remove type II temporary pavement marking tape, it shall be removed without the use of solvents or grinding and without damage to the pavement or shoulder surface.

500 3. **Temporary Raised Pavement Marker.** The temporary raised pavement marker shall be used where supplemental delineation is needed. The temporary raised pavement marker shall be grade 1 or grade 2. The grade 1 and grade 2 temporary raised pavement markers shall be used as a supplement to temporary pavement marking tape. The color of the reflector shall be in conformance with the tape. The color of the shell of the grade 1 marker shall be in conformance with the color of the tape.

4. **Buzz Strips.** Buzz strips shall consist of placement of a set of transverse markings for warning traffic of a construction zone, in accordance with 105.03.

510 The pavement shall be cleaned of all debris before installation of buzz strips. Durable marking material in accordance with 913.14(b) shall be used to attain the specified height. Buzz strips shall be removed when determined to no longer be required.

(b) **Marking Method On Two-Lane Pavements.** When a bituminous base or surface overlay course is being placed on a two-lane pavement which is open to traffic, a dashed line pavement marking pattern using 100 mm (4 in.) Type I or Type II temporary tape shall be placed on the center line before the close of work each day. These temporary pavement markings shall be yellow for two way roadways and shall be white for one way roadways. Temporary pavement markings on resurface projects shall be Type I or Type II temporary tape. All temporary markings shall be removed prior to placing the final markings.

520 (c) **Marking Method On Multi-Lane Pavements.**

1. Lane Line Markings.

a. **Base Course.** Lane line markings shall be 125 mm (5 in.) type II tape in the dashed pattern with a temporary raised pavement marker at the mid-point of the 11 m (36 ft) interval. The temporary tape may remain in place. Temporary raised pavement markers shall be removed prior to placing the next course.

530 b. **Intermediate Course.** Lane line markings shall be 125 mm (5 in.) type II tape in the dashed pattern with a temporary raised pavement marker at the midpoint of the 11 m (36 ft) interval. If the surface course is less than 60 kg/m² (110 lb/sq yd), the tape shall be removed prior to placing the surface and in this case may be either type I or type II. All temporary raised pavement markers shall be removed prior to placing the surface course.

c. **Surface.** Lane line markings shall be 125 mm (5 in.) type I tape in the dashed pattern with a temporary raised pavement marker at the midpoint of the 11 m (36 ft) interval. Type II may be used in lieu of Type I tape; however all temporary markings and temporary raised pavement markers shall be removed prior to placing the final markings.

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2. Gore Area Markings.

a. **Base Course.** The outline of the gore area shall be a solid 125 mm (5 in.) temporary tape, type II. Temporary raised pavement markers shall be placed adjacent to the solid stripe at 6 m (20 ft) intervals. The outside edge line shall be a solid 100 mm (4 in.) temporary tape, type II. The tape may remain in place. Temporary raised pavement markers shall be removed prior to placing the next course.

550 b. **Intermediate Course.** The outline of the gore area shall be a solid 125 mm (5 in.) temporary tape, type II. Temporary raised pavement markers shall be placed adjacent to the solid stripe at 6 m (20 ft) intervals. The outside edge line shall be a solid 100 mm (4 in.) temporary tape, type II. If the surface course is less than 54 kg/m², (100 lb/sq yd) the temporary tape may be type I or type II, and shall be removed prior to placing the surface course. All temporary raised pavement markers shall be removed prior to placing the surface course.

c. **Surface.** The gore area shall be outlined with a solid 203 mm (8 in.) durable pavement marking material. The outside edge line shall be a solid 100 mm (4 in.) durable pavement marking material. The durable marking material shall be in accordance with 808.06(b) and shall remain in place as the final markings.

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3. Acceleration, Deceleration, and Ramp Area Markings.

a. **Base Course.** The outside edge line shall be a solid 100 mm (4 in.) temporary tape, type II. The tape may remain in place.

b. **Intermediate Course.** The outside edge line shall be a solid 100 mm (4 in.) temporary tape, type II. If the surface course is less than 60 kg/m², (110 lb/sq yd) the temporary tape shall be removed prior to placing the surface course and in this case the tape may be either type I or type II.

c. **Surface.** The outside edge line shall be a solid 100 mm (4 in.) durable pavement marking material in accordance with 808.06(b) and shall remain in place as the final markings.

4. Narrow Bridge Markings.

a. **Base Course.** Parallel edge lines and the diagonal line on the shoulder approaching narrow bridges shall be a solid 100 mm (4 in.) temporary tape, type II. The temporary tape may remain in place.

b. **Intermediate Course.** Parallel edge lines and the diagonal line on the shoulder approaching narrow bridges shall be a solid 100 mm (4 in.) temporary tape, type II. If the surface course is to be less than 60 kg/m², (110 lb/sq yd) the temporary tape shall be removed prior to placing the surface course. The tape may be either type I or type II.

c. **Surface.** Parallel edge lines approaching narrow bridges shall be a solid 100 mm (4 in.) durable pavement marking material in accordance with 808.06(b). The durable pavement marking material shall remain in place as the final markings. The diagonal line on the shoulder shall be a solid 100 mm (4 in.) temporary tape, type I. It shall be removed prior to sealing the shoulder.

5. **Time of Installation.** As the HMA surface is finished, the durable pavement marking material shall be placed before the close of work each day. This shall include the marking patterns of gore area outlines, outside edge lines of deceleration and acceleration lanes, and narrow bridge markings.

801.15 Traffic Control for Temporary Traffic Stoppage. Traffic stoppage during an overhead span installation shall not exceed 20 min at one time. There shall be enough time between consecutive stoppages to permit traffic to return to normal flow. Traffic shall not be permitted to pass directly beneath personnel working on an overhead structure.

Three working days prior to commencing work which will necessitate temporary stoppage of traffic, written notice shall be given to the Department and the Indiana State Police that highway traffic will be stopped temporarily at a specific location, time, and date to accomplish specified work. Traffic shall be safely controlled during the stoppage. The following minimum requirements shall be met.

(a) **On Multi-Lane Divided Highways.** Advance warning signs shall be located as specified, or as otherwise directed. In addition, a minimum of four flaggers will be required to control traffic and eight flaggers will be required for road closure in both directions. If the road is closed in one direction, two flaggers shall be located at the

site of the work and the other two shall be used to warn approaching traffic. If the road is closed in both directions, four flaggers shall be located at the site of the work and two shall warn approaching traffic in each direction.

620 (b) **On Non-Divided Highways.** Advance warning signs shall be located as specified, or as otherwise directed. There shall be a minimum of four flaggers required to control traffic. Two flaggers shall be located at the site of the work and the others shall be used to warn approaching traffic.

801.16 Maintenance of Traffic for Snowplowable Marker or Reflector Installation. Signs, cones, flagging, flashing arrow signs, and other required traffic protection devices shall be furnished in accordance with the details shown on the plans or as directed. The Engineer will reserve the right to stop work in order to relieve traffic congestion. The installation of snowplowable raised pavement markers or replacement of prismatic reflectors in existing castings will be considered to be a moving operation.

630 **801.17 Method of Measurement.** Construction signs, detour route marker assemblies including supports, temporary worksite speed limit sign assemblies, road closure sign assemblies including supports, and temporary raised pavement markers will be measured by the number of units installed, maintained, and removed.

Type III-A barricades, permanent type III-A barricades, and type III-B barricades will be measured by the number of 3.6 m (12 ft) sections installed, maintained, and removed.

640 Flashing arrow signs will be measured by the number of calendar days each unit is operated.

Temporary pavement markings will be measured by the meter (linear foot) of tape or paint actually placed. Buzz strips will be measured by the meter (linear foot) for each strip, without regard to the number of passes required to attain the specified height.

Cones, flexible channelizers, and tubular markers will not be measured for payment.

650 Temporary illumination and maintaining traffic will not be measured for payment. Removal and subsequent replacement of prismatic reflectors from snowplowable raised pavement markers and removal of existing pavement markings will not be measured for payment unless provided for in the Schedule of Pay Items.

660 **801.18 Basis of Payment.** The accepted quantities of construction signs, detour route marker assemblies, temporary worksite speed limit sign assemblies, road closure sign assemblies, and temporary raised pavement markers will be paid for at the contract unit price per each. Payment for temporary worksite speed limit assemblies will be made for the maximum number of such assemblies in place during the contract time. Type III-A barricades, permanent type III-A barricades, and type III-B barricades will be paid for at the contract unit price per each 3.6 m (12 ft) section.

If more than one construction sign is mounted on a common support, the additional signs will be paid for at one half the price of the sign if it had been erected independently. "No Left Turn" "Into Driveways" construction sign assemblies used with flexible channelizer and tubular marker traffic separation will be paid for in this manner.

Flashing arrow signs will be paid for at the contract unit price per day per each.

670 Painted lines, temporary pavement marking tape, and buzz strips, will be paid for at the contract unit price per meter (linear foot), complete in place, except as set out below.

If temporary pavement marking type I is used in lieu of temporary pavement marking type II, payment will be made at the contract unit price for temporary pavement marking type II.

Temporary illumination will be paid for at the contract lump sum price.

680 All traffic control devices and construction materials which are specified as separate pay items and used for maintenance of traffic will be paid for as set out in the Schedule of Pay Items unless otherwise specified.

The furnishing, placing, moving, removal, and maintenance of all other traffic control devices will be paid for at the contract lump sum price for maintaining traffic.

Payment will be made under:

	Pay Item Metric Pay Unit Symbol	(English Pay Unit Symbol)
	Metric Pay Item	Metric Pay Unit Symbol
	(English Pay Item	English Pay Unit Symbol)
690	Barricade, _____	EACH
	type	
	Barricade, III-A, Permanent	EACH
	Buzz Strips	m (LFT)
	Construction Sign, _____	EACH
	type	
	Detour Route Marker Assembly	EACH
	Flashing Arrow Sign	DAY
	Maintaining Traffic	LS
700	Road Closure Sign Assembly	EACH
	Temporary Illumination	LS
	Temporary Pavement Marking, _____, _____, _____ mm.....	m
	type color width	
	(Temporary Pavement Marking, _____, _____, _____ in.	LFT)
	type color width	
	Temporary Raised Pavement Marker, _____	EACH
	grade	
	Temporary Worksite Speed Limit Sign Assembly	EACH

710 The costs of installation, maintenance, operation, relocation, removal, and all necessary incidentals shall be included in the costs of the pay items.

The costs of furnishing, installing, maintaining, and subsequent removal shall be included in the cost of temporary raised pavement marker.

720 The costs of furnishing, installing, maintaining, and subsequent removal of HMA divider, tubular markers, and traffic paint shall be included in the cost of temporary HMA divider. The costs of cleaning existing pavement and removal of buzz strips shall be included in the cost of buzz strips. Damage to the pavement caused by removal of the HMA divider and buzz strips shall be repaired as directed with no additional payment.

No payment will be made for temporary pavement markings on road resurfacing work which are in the standard pavement marking pattern, and which are to be in service from December 1 through the following March 31. If such markings are paved over prior to December 1, they will be paid for as temporary pavement markings.

730 The costs of furnishing, installing, maintaining, and subsequent removal of the detour marker, route marker, or street or road name sign, cardinal directional marker, directional arrow marker, posts which support the assembly, and all necessary hardware shall be included in the cost of detour route marker assembly.

The costs of installing, maintaining, and subsequent removal of signs, type B construction warning lights, assembly supports, and all necessary hardware shall be included in the cost of road closure sign assembly.

740 The costs of furnishing all materials, erection, maintenance, lights, removal, and necessary incidentals shall be included in the costs of barricades. However, each sign, barricade, temporary worksite speed limit sign assembly, or flashing arrow sign will be paid for only once regardless of how many times each is moved, replaced, or how many times each is altered to change the sign message. Payment will not be made for signs or barricades used for the convenience of the Contractor.

No additional payment will be made for the backup temporary worksite speed limit sign assembly. If a temporary worksite speed limit sign assembly is not flashing when required beginning 2 h after notification, or if such assembly is flashing when no work has been taking place for 2 h or longer, \$200.00 will be deducted from payment for such work for each 4 h period after the Contractor is informed that such assembly is not functioning properly.

750 Construction signs, barricades, and other temporary traffic control devices furnished by the Contractor shall remain the property of the Contractor. Such devices shall be covered or removed from the work as directed. Permanent type III-A barricades, used at the locations shown on the plans, shall remain in place on completion of the contract. Such barricades will become the property of the Department.

If the Contractor elects to use more than two simultaneous operations during the installation of snowplowable pavement markers or reflectors, the costs of required traffic protection devices for additional operations shall be included in the cost of maintaining

760 traffic. The costs of necessary watchers and flaggers; protection of traffic at structure foundations; and furnishing, erecting, placing, maintaining, relocating, and removing lights, cones, flexible channelizers, tubular markers, drums, delineators, temporary pavement markings, or other devices as directed shall be included in the cost of maintaining traffic.

The costs of removal and subsequent replacement of prismatic reflectors in snowplowable raised pavement markers, and removal of conflicting pavement markings shall be included in the costs of other pay items unless otherwise provided for in the Schedule of Pay Items.

770 The costs of furnishing and placing cones or tubular markers in accordance with 801.08 and drums in accordance with 801.10, the 24-hour watcher if required, repair or replacement of damaged or inoperative traffic control devices, and traffic maintenance in accordance with 108.03 shall be included in the cost of maintaining traffic. The costs of furnishing, placing, maintaining, removal, and disposal of temporary drainage structures shall be included in the cost of maintaining traffic.

SECTION 802 -- GROUND MOUNTED SIGNS

802.01 Description. This work shall consist of furnishing the material for and erecting traffic signs in accordance with these specifications and in reasonably close conformance with the lines, grades, and locations shown on the plans. Signs shall be installed as required unless written approval is obtained from the District Traffic Engineer to make modifications at specific locations.

10 All signs shall be transported and stored in an upright fashion. Each sheet sign face shall have the plastic side of the slip sheeting placed against it during transport and storage. Microfoam padding shall be in place between signs with high intensity sheeting. Panel signs shall be transported and stored in shipping containers so that the faces do not touch anything. Signs shall be stored in such a manner that they are not on the ground nor come in contact with surface run-off water. Signs shall be stored so that moisture accumulation or heat build-up does not occur.

20 All signs shall be marked for identification. The marking shall consist of a pressure sensitive material shown on the Department Approved Materials List, and shall be applied to the back of the sign. The identifying message shall consist of INDOT and the month and year the sign is installed. The message copy shall consist of black lettering of a minimum of 25 mm (1 in.) in height. The marking background shall be white. The marking for sheet signs shall be placed in the lower corner closest to the center-line of the road. The marking for panel signs shall be placed on the bottom panel on the end closest to the centerline of the roadway. The marking shall not be covered by the sign's supports after installation of the sign.

MATERIALS

30 **802.02 Materials.** Materials shall be in accordance with the following:

Paint and Enamel	909
Reinforcing Steel.....	910.01
Sign Posts	910.14, 911.02(e)
Traffic Signs	913.10

Concrete shall be in accordance with 702, class A or B, or for packaged dry concrete in accordance with 913.17.

CONSTRUCTION REQUIREMENTS

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802.03 Location of Signs. The location of each sign will be established longitudinally and each location will be marked with the number of the respective sign, either by a stake or by painting on the pavement. The locations of the sign supports shall be staked, and the Engineer, who will either approve the locations or make necessary changes, shall be informed. Sheet signs and posts shall not be ordered until the exact number of signs and length of each post has been determined upon a field investigation.

50

The break-away stubs shall be installed prior to ordering the posts. Final length of the break-away posts shall be determined by using the elevation of the finished stub installation.

When the staked locations have been approved, the stakes shall be replaced with signs and all work completed. All signs shall be placed at the proper elevation, offset, level, and be oriented correctly. If specular reflection is apparent in any sign, the sign face shall be adjusted to eliminate this condition with no additional payment.

60

The cost of furnishing all stakes and of performing the layout as described above shall be included in the contract prices for the various specified pay items. No less than two days notice shall be provided in advance of the time when staking or inspection is required. Each request for staking or other engineering services required as above described shall, except in emergency, cover sufficient work for no less than one full day of the force needed for the work.

70

802.04 Excavation. Necessary excavation for sign installation shall be completed to the levels and dimensions shown on the plans or as directed. Excavations may be accomplished either manually or mechanically, but in no way shall the finished pavement or shoulder section be damaged during such excavation. All material shall be removed to the full depth as shown on the plans, except if class X material is encountered during excavation, the work shall be performed in accordance with 206.02(b). All excavated material that is not needed to backfill and level the disturbed area within 24 h after completion of the work shall be removed from the site.

802.05 Installing Posts and Signs. Posts shall be as shown on the plans, firm in the ground, and set at the required line and grade. Any post which is not acceptable shall be removed and redriven. Posts shall be placed vertically and signs, when attached, shall be aligned accurately.

80 The excavation for sign posts shall be made as nearly to neat lines as possible and all parts of the sign post encasement poured against the soil or rock face without forming, except in sandy soil, or as directed or permitted.

If forms for encasement are used, they shall not be removed in less than 18 h after the concrete is poured. The backfill around the foundations shall be placed in 150 mm (6 in.) layers and each layer tamped. Posts set in concrete shall be held in proper position during encasing and backfilling operations. Exposed concrete shall have a smooth surface finished to the slope shown on the plans. Edges shall be beveled as specified.

90 Flanged channel posts, when specified to be driven, may be driven by hand or mechanical devices to the required line and grade and shall be approximately plumb. During driving, posts shall be protected by a special driving cap. Any post bent or otherwise damaged so as to be unfit for use in the finished work shall be removed from the site and replaced with an acceptable post with no additional payment.

Square sign posts shall be as shown on the plans. Sign post foundations shall be reinforced anchor base or unreinforced anchor base as shown on the plans. If sign post type A or sign post type B is specified, square sign posts may be used in lieu of such types as shown on the plans. Splicing of square steel sign posts will not be permitted for permanent new installations on contract work.

100 Signs shall be installed as shown in the plans. The signs shall be fastened to the posts by bolts, locknuts, and metal and plastic washers in accordance with 913.10(a). The plastic washer shall be installed next to the sign face with the sheeting, and the flat metal washer shall be installed next to it, and then the bolt installed. The bolt shall be installed with the bolt head on the face of the sign and the locknut on the back of the post. Locknut shall be tightened sufficiently so that the sign is held firmly against the post. If there is any sign face twisting or damage, the sign shall be replaced.

110 **802.06 Removal or Relocation of Signs or Support Assemblies.** All existing signs directed to be relocated and are within 0.6 m (2 ft) of a paved shoulder shall be removed. The signs to be relocated shall be installed on new posts and the edges of the signs shall be placed a minimum of 1.8 m (6 ft) outside of the edge of the paved shoulder, or as directed. The post type and length shall be as directed.

120 Signs or support assemblies not directed to be relocated shall be removed as shown on the plans or as otherwise directed. Such signs or support assemblies shall be removed within five work days after the required replacement signs or support assemblies are installed. Concrete foundations for wide flange support assemblies shall be removed to a minimum depth of 0.3 m (1 ft.) below the ground surface. Concrete foundations for channel post support assemblies shall be completely removed. After concrete foundations have been removed, the area shall be backfilled with clean fill, seeded or sodded in accordance with 621, or treated with a material which matches that in the surrounding area.

802.07 Remove and Reset Roadway and Bridge Reference Signs. If existing roadway and bridge reference signs interfere with the prosecution of other work, such signs and posts shall be removed as directed. They shall be stored in the location directed. They shall then be reinstalled within 15 m (50 ft) of their original longitudinal location or as directed.

130 If new signs are to be installed on existing structures, the existing mounting hardware, if adaptable, may be reused. Additional new hardware may be required to complete the mounting. All such sign hangers protruding above the new signs shall be cut off flush to the top of the signs. Splicing or overlapping of sign hangers will not be permitted. All unused sign hangers and hardware shall be removed.

802.08 Shop Drawings of Signs and Sign Structures. Unless otherwise specified, the Department will furnish two sets of shop drawings for panel and sheet signs, except for the sheet signs illustrated in the Standard Highway Signs published by the FHWA. Shop drawings for flanged channel posts and wide flanged posts will not be required.

140 **802.09 Final Clean-Up.** Before final acceptance, touching up of paint surfaces, cleaning of exposed sign and support surfaces, leveling, and repair of the site as may be necessary to ensure the effectiveness and neat appearance of the work shall be performed.

802.10 Method of Measurement. Sheet signs and panel signs will be measured by the square meter (square foot). Sheet signs will be measured as the smallest dimensions of a square or rectangle large enough to make the sign. However, triangular or trapezoidal signs will be measured as the smallest triangle or trapezoid required to make the sign. If set out as pay items, letters, symbols, numbers, arrows, radii, or accessories will be measured by the number of units of the sizes and types installed. Sign borders will be measured by the meter (linear foot). Sign posts will be measured by the meter (linear foot). Square sign posts will be measured from the top of the post to the termination of the post in the anchor base as shown on the plans. Reinforcing steel will be measured by the kilogram (pound) in accordance with 703.07. Concrete foundations will be measured by the cubic meter (cubic yard) in accordance with 702.27. If class X material is encountered during foundation excavation, the quantity to be measured will be that authorized and removed. No reduction will be made for reinforcing steel, structural steel, or conduit. Structural steel will be measured by the kilogram (pound). Such measurement will include the mass (weight) of breakaway sections such as stubs, stiffeners, base plates, and fuse plates. For rigid sections, the mass (weight) of the base plate will be included. Reference posts, including post, sign, and hardware, will be measured by the number of units installed.

160 If the pay unit for sheet signs is shown in the Schedule of Pay Items as each, the number of sheet signs specified, including posts, hardware, and erection, will be measured by the number of units installed.

802.11 Basis of Payment. The accepted quantities of sheet signs and panel signs will be paid for at the contract unit price per square meter (square yard), for sign, sheet or sign, panel as specified, of the type specified, with legend, of the thickness specified, complete in place. Sign post will be paid for at the contract unit price per meter (linear

foot) for the type specified. Structural steel and reinforcing steel will be paid for at the contract unit price per kilogram (pound). Concrete foundations will be paid for at the contract unit price per cubic meter (cubic yard). Reference posts will be paid for at the contract unit price per each, complete in place. If class X material is encountered during a foundation excavation, payment will be made in accordance with 206.11(d).

The removal of signs, sign assemblies, supports, or concrete foundations will be paid for at the contract unit price per each.

180 Payment will be made under:

	Metric Pay Item (English Pay Item Pay Item Metric Pay Unit Symbol	Metric Pay Unit Symbol (English Pay Unit Symbol)
	Reference Post.....	EACH
	Reinforcing Steel, Sign Foundation.....	kg (LBS)
	Sign and Supports, Channel Post, Remove.....	EACH
	Sign and Supports, Wide Flange, Remove	EACH
190	Sign Foundation, Concrete	m3 (CYS)
	Sign, Overhead, Remove	EACH
	Sign, Panel, _____, With Legend.....	m2 (SFT)
	type	
	Sign Post, _____	m (LFT)
	type	
	Sign Post, Square, _____, Reinforced Anchor Base.....	m (LFT)
	type	
	Sign Post, Square, _____, Unreinforced Anchor Base	m (LFT)
	type	
200	Structural Steel, Breakaway	kg (LBS)
	Sign, Sheet, With Legend	EACH
	Sign, Sheet, _____, With Legend, _____	m2
	type thickness	
	(Sign, Sheet, _____, With Legend, _____	SFT)
	type thickness	

The costs of all hardware necessary to assemble and attach the sign to its structural supports, and all legend or copy if specified, shall be included in the cost of sheet sign or panel sign.

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The costs of all necessary hardware including sign hangers, clips, and U bolts required for the mounting of signs to existing or new overhead sign structures shall be included in the cost of the sign face.

The costs of the reinforced anchor base or unreinforced anchor base, angle bolts, and rivets shall be included in the cost of sign post, square.

220 If new signs are to be installed on existing structures, the costs of cutting of existing sign hangers to flush them to the tops of signs shall be included in the cost of overhead sign removal. The cost of anchor bolts required for rigid post installation shall be included in the cost of such posts. The costs of excavation, hauling, installation, identification markings, and all necessary incidentals shall be included in the costs of the pay items.

The costs of signs directed to be removed and relocated, including the sign removal, existing post removal, all hardware necessary to attach the existing sign, and existing sign installation shall be included in the cost of the new sign posts.

230 The cost of roadway and bridge reference signs and posts to be removed, stored, and reinstalled shall be included in the costs of other pay items, unless otherwise specified. Roadway and bridge reference signs which are damaged by the Contractor shall be replaced with no additional payment.

SECTION 803 -- OVERHEAD SIGN STRUCTURES

803.01 Description. This work shall consist of furnishing and erecting overhead sign structures and sign lighting in accordance with these specifications and in reasonably close conformance with the lines and grades and at locations shown on the plans or as directed. Overhead sign structures are those which support signs over the traveled way.

MATERIALS

10 **803.02 Materials.** Materials shall be in accordance with the following:

Concrete, Class A, B, or C.....	702
Overhead Sign Structures.....	910.19
Reinforcing Steel.....	910.01
Sign Lighting	913.11

CONSTRUCTION REQUIREMENTS

20 **803.03 Shop Drawings.** Prior to fabrication, six sets of shop drawings for all overhead sign structures, except bridge brackets, shall be submitted in accordance with 711.05. Roadway cross sections and bridge dimensions shall be checked as applicable in the field prior to preparation of shop drawings. If any discrepancies are found, the Engineer shall be notified so necessary design revisions can be made prior to preparation of the shop drawings. If the no-load camber is not shown on the plans, the Contractor shall furnish this camber in the shop drawings.

803.04 Excavation. Excavation shall be in accordance with 802.04.

30 **803.05 Placing Concrete.** Placing concrete shall be in accordance with 702, except that footings incorporated into sections of concrete barrier wall shall have a Class 2, rubbed finish.

803.06 Erection. The structure shall be handled carefully during loading, shipment, unloading, and erection to avoid damage to any member of the structure. The structure shall be inspected before unloading, during all operations, and until erection is completed. Damage detected at any time shall be repaired before final acceptance. When being erected, the structural members shall be lifted by means of nylon straps placed around them, or by other approved methods which do not damage the structure. Field welding of aluminum shall be in accordance with 803.07. Field welding of steel shall be in accordance with applicable provisions of 711.32. The Contractor shall ensure the proper fit of the structure to end bent extensions and of the end bent extension to the foundation anchor bolts. When erection of the structure has been started, it shall be completed that same day. The structure shall be loaded to prevent vibration by attaching signs or lighting supports the same day. A minimum of two sign support bracket assemblies will be required for all signs having a width greater than 760 mm (30 in.). Signs 2.1 m (7 ft) or less in height shall have sign support bracket assemblies mounted at a maximum spacing of 2.1 m (7 ft). Signs greater than 2.1 m (7 ft) in height shall have sign support bracket assemblies mounted at a maximum spacing of 1.5 m (5 ft). Sign overhang beyond the end bracket assembly shall be not more than half the spacing of the bracket assemblies.

Nuts for cable span mounted signs shall be tightened so that the sign is held firmly against the cable. There shall be no deformation or twisting of aluminum sheeting, or damage to the reflective sheeting.

(a) Under Traffic. During the erection of overhead sign structures, traffic shall be safely controlled in accordance with 801.15. The minimum requirement for a traffic lane closure shall be as set out on the plans. Additional signs, barricades, and other traffic control devices may be required as directed.

(b) Trusses. When placed on blocks to produce the required camber, the truss sections shall fit together at the flange connections with a minimum gap of 1.5 mm (1/16 in.) on any flange assembly. The total of the gaps in any one connection shall not exceed 3 mm (1/8 in.). Gaps shall be shimmed with tapered shims before tightening the flange bolts.

All signs and walkway brackets shall be placed as close to the brace points as possible. The Contractor shall verify that the dimensions are suitable for the type of fixture to be supplied.

(c) Monotube. When placed on blocks to produce the required camber, beam halves shall fit together at the flange connections with a minimum gap of 1.5 mm (1/16 in.) on any flange assembly. Gaps shall be shimmed with tapered shims before tightening the flange bolts.

(d) Cantilever. Arms shall fit together at the flange connections between sections with a minimum gap of 1.5 mm (1/16 in.) on any flange assembly. The total of the gaps in any one connection shall not exceed 3 mm (1/8 in.). Gaps shall be shimmed with tapered shims before tightening the flange bolts.

80 **(e) Bridge Brackets.** Bridge brackets shall be erected as shown on the plans. Sign location may be shifted to avoid joints or stiffeners. Before placing aluminum in contact with concrete, the concrete shall be coated with an aluminum-impregnated caulking compound. Aluminum surfaces to be placed in contact with steel shall be given one coat of zinc chromate before placement. Such aluminum surface shall be coated with an aluminum-impregnating caulking compound. After the bolts have been tightened, the excess caulking compound shall be removed. All openings around the flanges shall be fully painted and shall be flush with the caulking compound.

90 **803.07 Welding Aluminum Alloys for Highway Structures.** These specifications apply to the welding of aluminum alloys used in sign structures, bridge rails, lamp posts, etc. The welding terms used shall be interpreted in accordance with definitions given in the latest edition of AWS Definitions "MD" Welding and Cutting, AWS A3.0. The welding symbols used on plans shall be those shown in the latest edition of Standard Welding Symbols, AWS A2.0. Special conditions shall be fully explained by added notes or details.

(a) Base Metals. The aluminum alloys to be welded under these specifications may be any of the following ASTM alloy designations:

- 100 1. wrought non-heat-treatable alloys 3003, 3004, 5052, 5083, 5086, 5456;
2. wrought heat-treatable alloys 6061, 6063; or
3. cast heat-treatable alloy 356.0.

 Material used for permanent backing shall be at least equivalent in weldability to the base metal being welded.

110 **(b) Welding Processes.** These specifications include provisions for welding by the gas metal-arc process and the gas tungsten-arc process. Other processes shall not be used except as permitted.

(c) Filler Metal. Bare wire electrodes for use with the gas metal arc process and welding rods for use with the gas tungsten-arc process shall be in accordance with the latest edition of Specifications for Aluminum and Aluminum Alloy Welding Rods and Bare Electrodes, ASTM B 285 or AWS A5.10. Tungsten electrodes for the gas tungsten-arc process shall be in accordance with in the latest edition of Specifications for Tungsten-Arc Welding Electrodes, ASTM B 297 or AWS A5.12.

120 Filler metals to be used with particular base metals shall be as shown in the table below. Other filler metals may be used if approved.

Base Metal	Filler Metal
3003 to 3003.....	ER1100
3004 to 3004.....	ER4043
5052 to 5052.....	ER5356*
5083 to 5083.....	ER5183

	5086 to 5086.....	ER5356*
	5456 to 5456.....	ER5556
130	6061 to 6061.....	ER5356*
	6063 to 6063.....	ER5356*
	356.0 to 6061.....	ER4043
	356.0 to 6063.....	ER4043

*ER5183, ER5356, and ER5556 may be used interchangeably for these base metals.

140 Filler metals shall be kept covered and stored in a dry place at relatively uniform temperatures. Original rod and wire containers shall not be opened until time to be used. Rod and wire shall be free of moisture, lubricant, or other contaminants. Spools of wire temporarily left unused on the welding machine shall be kept covered to avoid contamination by dirt and grease collecting on the wire. If a spool of wire is to be unused for more than a short length of time, it shall be returned to the carton and the carton tightly sealed.

150 (d) **Shielding Gases.** Shielding gases shall be welding grade or better. Shielding gas for gas metal-arc welding shall be argon, helium, or a mixture of the two, approximately 75% helium and 25% argon. Shielding gas for gas tungsten-arc welding done with alternating current shall be argon. Shielding gas for gas tungsten-arc welding done with direct current, straight-polarity, shall be helium.

Hose used for shielding gases shall be made of synthetic rubber or plastic. Natural rubber hose shall not be used. Hose which has been used previously for acetylene or other gases shall not be used.

(e) **Preparation of Materials.** Joint details shall be in accordance with design requirements and detail drawings. The location of joints shall not be changed without approval.

160 Edge preparation shall be by sawing, machining, clipping, or shearing. Gas tungsten-arc or gas metal-arc cutting may also be used. Cut surfaces shall meet the ANSI surface roughness rating value of 1000. Oxygen cutting shall not be used.

Surfaces and edges to be welded shall be free from fins, tears, and other defects which would affect adversely the quality of the weld. Dirt, grease, forming or machining lubricants, or any organic materials shall be removed from the areas to be welded by cleaning with a suitable solvent or by vapor degreasing.

170 On all edges and surfaces to be welded, the oxide shall be removed just prior to welding by wire brushing or by other mechanical methods such as rubbing with steel wool or abrasive cloth, scraping, filing, rotary planing, or sanding. If wire brushing is used, the brushes shall be made of stainless steel. Hand or power driven wire brushes which have been used on other materials shall not be used on aluminum. Where mechanical methods of oxide removal are found to be inadequate, a standard chemical method shall be used. Welding shall be done within 24 h after chemical treatment. When

gas tungsten-arc welding with direct current straight-polarity is being used, all edges and surfaces to be welded shall have the oxide removed by a standard chemical method.

Welding shall not be done on anodically treated aluminum unless the condition is removed from the joint area to be welded.

180

(f) Welding Procedure. All butt welds requiring 100% penetration, except those produced with the aid of backing, shall have the root of the initial weld chipped or machined out to sound metal before welding is started from the second side. Butt welds made with the use of backing shall have the weld metal fused with the backing. Where accessible, backing for welds, that are subject to computed stress or which are exposed to view on the completed structure and which are not otherwise parts of the structure, shall be removed and the joints ground or machined smooth. In tubular members, butt welds subjected to computed stresses shall be made with the aid of permanent backing rings or strips.

190

The procedure used for production welding of any particular joint shall be the same as used in the procedure qualification for that joint.

All welding operations, either shop or field, shall be protected from air currents or drafts so as to prevent any loss of gas shielding during welding. Adequate gas shielding shall be provided to protect the molten metal during solidification. The work shall be positioned for flat position welding whenever practicable. In both shop and field, all weld joints shall be dry at time of welding.

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The size of the electrode, voltage and amperage, welding speed, gas or gas mixture, and gas flow rate shall be suitable for the thickness of the material, design of joint, welding position, and other circumstances attending the work. Gas metal-arc welding shall be done with direct current, reverse polarity. Gas tungsten-arc welding shall be done with alternating current or with direct current, straight polarity.

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When the joint to be welded requires specific root penetration, a sample joint shall be made and a macro etched cross section of the weld to demonstrate that the joint welding procedure to be used is attaining the required root penetration. The sample joint shall have a length of at least 0.3 m (1 ft) and shall be welded with the electrode, polarity, amperage, voltage, speed, gas mixture, and gas flow rate that are proposed to be used in production welding. Evidence on record may be accepted in lieu of the preceding test.

Where preheat is needed, the temperature of preheat shall not exceed 177°C (350°F) for heat-treated alloys and 316°C (600°F) for nonheattreated alloys. The temperature shall be measured by temperature indicating crayons or by pyrometric equipment. Heat-treated alloys shall not be held at the maximum preheat temperature or at temperatures near the maximum for more than 30 min.

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(g) Weld Quality. Regardless of the method of inspection, the acceptance or rejection of welds shall be determined by the following conditions:

1. Cracks in welds or adjacent base metal will not be acceptable.

- 2 Copper inclusions will not be acceptable.
3. Porosity in excess of that permitted by Appendix IV, Section VIII, of the ASME Boiler and Pressure Vessel Code will not be acceptable.
4. Lack of fusion, incomplete penetration, or tungsten or oxide inclusions will be acceptable only if small and well dispersed.

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Undercut shall be no more than 0.3 mm (0.01 in.) deep when its direction is transverse to the primary stress in the part that is undercut. Undercut shall be no more than 0.8 mm (1/32 in.) deep when its direction is parallel to the primary stress in the part that is undercut. No overlap shall be allowed. All craters shall be filled to the full cross section of the welds. Welds having defects greater than the levels of acceptance specified herein shall be considered as rejected unless corrected in accordance with 803.07(i).

240 (h) **Inspection.** To determine compliance with 803.07(g), all welds shall be inspected visually. In addition, all welds subjected to computed stress shall be inspected by the dye penetrant method except as specified below. For highway sign structures, the dye penetrant method shall be used on butt welds in columns and main chord members; on fillet welds connecting columns to bases and main chord members, including the associated flanges, gussets, or main load carrying brackets or members; and on fillet welds connecting flanges to the main truss chord members. The dye penetrant tests shall be performed in accordance with the requirements of ASTM E 165, method B, procedures B-2 or B-3. Dye penetrant inspection may be omitted provided that the inspector examines each layer of weld metal with a magnifier of 3X minimum before the next successive layer is deposited.

250 (i) **Corrections.** In lieu of rejection of an entire piece or member containing welding which is unacceptable, the corrective measures listed below may be permitted if approval is obtained prior to making each repair. Defective welds shall be corrected by removing and replacing the entire weld, or as follows:

1. For cracks in welds or base metal, determine full extent of crack by dye penetrant method or other positive means. Remove crack throughout its length and depth, and reweld.
2. For excessive porosity and lack of fusion, remove defective portions and reweld.
3. For copper or tungsten inclusions, remove defective portions and reweld.
4. For excessive concavity of crater, undercut and undersize weld, clean and deposit additional weld metal.
5. For Overlap, reduce it by removal of excess of weld metal.

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270 The defective areas shall be removed by chipping or machining. Oxygen cutting shall not be used. Before rewelding, the joint shall be inspected to ensure that all of the

defective weld has been removed. If dye penetrant has been used to inspect the weld, all traces of penetrant solutions shall be removed with solvent, water, heat, or other suitable means before rewelding.

280 (j) **Qualification of Procedures, Welders, and Welding Operators.** Joint welding procedures which are to be employed in executing contract work under these specifications shall be qualified previously by tests prescribed in Part B, Section IX, of the ASME Boiler and Pressure Vessel Code. The qualifications shall be done with no additional payment. Evidence of previous qualification of the joint welding procedures to be employed may be accepted.

All welders and welding operators to be employed under these specifications shall be qualified previously by tests in accordance with Part B, Section IX, of the ASME Boiler and Pressure Vessel Code and 916. Evidence of previous qualification of the welders and welding operators to be employed may be accepted. The same process and type of equipment that is required for execution of the construction work shall be used in qualifying welders and welding operators.

290 **803.08 Removal of Overhead Signs and Sign Structures.** Existing overhead signs and sign structures such as box trusses, cantilevers, monotubes, twin cantilevers, or tri-chord trusses shall be removed as shown on the plans or otherwise directed. Such existing overhead signs and sign structures shall be removed within five work days after the required replacement signs and sign structures are completely installed. After overhead signs or structures have been removed, their foundations shall be removed to a minimum depth of 0.3 m (1 ft) below the ground surface. The area shall be backfilled with clean fill, reseeded or sodded in accordance with 621, or replaced with a material which matches that in the surrounding area.

300 **803.09 Final Clean-Up.** Final clean-up shall be in accordance with 104.07 and 802.09.

310 **803.10 Method of Measurement.** Span overhead sign structures, overhead sign structures, bridge bracket assemblies, and sign lighting installations will be measured by the number of units of each type installed. Concrete foundations will be measured by the cubic meter (cubic yard) within neat lines as shown on the plans or as revised. No deductions will be made for reinforcing steel, structural steel, or conduit. Reinforcing steel will be measured by the kilogram (pound) in accordance with 703.07. If class X material is encountered during a foundation excavation, measurement will be made in accordance with 206.10.

Sign lighting installation, including all connectors, wiring, conduit, and miscellaneous hardware, except luminaires, will be measured per each type of lighting installed.

Overhead sign structures to be removed will be measured by the number of structures removed.

320 **803.11 Basis of Payment.** The accepted quantities of span overhead sign structures, overhead sign structures, bridge bracket assemblies, and sign lighting

installations will be paid for at the contract unit price per each, all complete in place. Concrete foundations will be paid for at the contract unit price per cubic meter (cubic yard) complete in place. Reinforcing steel will be paid for at the contract unit price per kilogram (pound). All necessary hardware for mounting signs to overhead sign structures will be paid for in accordance with 802.10.

Overhead sign structures to be removed will be paid for at the contract unit price per each of the type specified.

330 Payment will be made under:

	Pay Item	Metric Pay Unit	Symbol	(English Pay Unit Symbol)
	Bridge Bracket Assembly			EACH
	Overhead Sign Structure, _____			EACH
	type			
	Overhead Sign Structure, _____, Remove			EACH
	type			
	Reinforcing Steel, Sign Foundation			kg (LBS)
340	Sign Circuit Installation, _____, _____			EACH
	type no.			
	Sign Foundation, Concrete			m3 (CYS)
	Span Overhead Sign Structure, _____			EACH
	type			

The costs of removal of signs, sign assemblies, sign lighting circuitry, supports, concrete foundations, backfill material, sodding, seeding, and necessary incidentals shall be included in the cost of overhead sign structure, remove.

350 The costs of excavation, backfill, and necessary incidentals shall be included in the costs of the pay items unless class X material is encountered during foundation excavation. Payment for such class X material will be made in accordance with 206.11(d).

SECTION 804 -- DELINEATORS

804.01 Description. This work shall consist of furnishing and erecting delineators in accordance with these specifications and in reasonably close conformance with the lines and grades and at locations shown on the plans. Delineators shall be installed as required unless approval is obtained from the District Traffic Engineer to make modifications at specific locations.

MATERIALS

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804.02 Materials. Materials shall be in accordance with the following:

Delineator Posts	910.15
Flexible Delineator Posts	913.07
Reflective Elements.....	913.08

The types of delineators shall be:

- 20
- (a) D1 - single white or single yellow;
 - (b) D2 - double white or double yellow.

Hardware for mounting delineators on posts shall be aluminum alloy 2024-T4; galvanized steel bolts 4.8 mm (3/16 in.) diameter with vandal proof nuts or lock-nuts; or aluminum pull-through blind rivets 4.8 mm (3/16 in) diameter.

CONSTRUCTION REQUIREMENTS

30 **804.03 Delineators and Barrier Delineators.** Delineators shall be placed as shown on the plans or in accordance with the AASHTO Manual for Signing Interstate Highways. A delineator shall not block an entrance. The delineator shall be moved a distance not to exceed one quarter of the basic spacing. If the conflict still exists, the delineator shall be eliminated. Delineators shall be installed at the back side of guardrail. When the guardrail run ends, and additional delineators are required, they shall be installed a minimum of 600 mm (2 ft) from the edge of the shoulder. Barrier delineators shall be used on temporary concrete barrier, concrete median barrier, concrete railing, and guard rail as shown on the plans or as specified. Delineator reflector units shall be positioned so as to be clearly visible for a distance of 305 m (1,000 ft) on tangent sections or at maximum visibility distances on curves. These locations shall be established under normal weather and atmospheric conditions when illuminated by the upper beam of standard automobile headlights.

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804.04 Posts. Posts shall be installed in accordance with applicable provisions of 802.

804.05 Flexible Delineator Posts. These posts shall be installed according to the manufacturer's recommended instructions and shall be set so that the top is no more than 13 mm (1/2 in.) from any vertical plane through the bottom. The erected height shall be in accordance with the MUTCD.

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804.06 Method of Measurement. Delineators with posts, delineator posts, and flexible delineator posts will be measured by the number of units of the type specified.

804.07 Basis of Payment. The accepted quantities of delineator with post, delineator post, and flexible delineator post, if set out as a separate pay item, will be paid for at the contract unit price per each for the type specified, complete in place.

Payment will be made under:

Delineator Post	EACH
Delineator Post, Flexible	EACH
Delineator with Post, _____ type	EACH

SECTION 805 -- TRAFFIC SIGNALS

805.01 Description. This work shall consist of furnishing miscellaneous materials, not furnished by the Department, and installing traffic signals in accordance with these specifications and in reasonably close conformance with the lines, grades, and locations shown on the plans or as directed.

MATERIALS

10 **805.02 Materials.** Materials shall be in accordance with the following:

Aggregate, Class A, B, C, D, or E size No. 8.....	904.02
Castings for Handhole.....	910.05(b)
Concrete, Class A, B, or C.....	702
Reinforced Concrete Pipe.....	907.02
Traffic Signal Materials and Equipment.....	913.15
Treated Lumber	911.02

20 The proposed work shall be examined in order to determine what materials not furnished by the Department are required to complete the contract. The Department will furnish only the materials specified on the Department Furnished Materials special provision. If materials to be furnished by the Contractor are listed, the list is only a guide for estimating purposes. All additional materials required to complete an operating installation as specified shall be furnished.

Signal handholes shall be class III reinforced concrete pipe as shown on the plans.

30 Wood poles to be furnished shall be in accordance with the current ANSI specifications and dimensions. They shall be of the length and class specified, be fully treated in accordance with 913.15(e)2, and dry. Minimum circumference at the top and at a point 1.8 m (6 ft) from the butt shall be in accordance with ANSI specifications.

Steel strain poles greater than 7.3 m (24 ft) in length shall be in accordance with 913.15(e)1b.

CONSTRUCTION REQUIREMENTS

40 **805.03 General Requirements.** The Contractor shall maintain existing traffic signals in operation until the Engineer determines that the progress of the work necessitates their removal. The new installation shall not interfere with the operation of the existing signal. The work shall proceed in such a manner that the signals are not out

of service at any two adjacent intersections at any time. When the operation of an existing traffic signal must be interrupted before the new signal is placed in operation, the traffic shall be controlled at all times. The work shall be scheduled so that the interruption is limited to a minimum amount of time and at off peak hours. When a new span, catenary, and tether are to be installed on an existing structure, the work shall be done so as not to damage the structure. Tether cable will not be required on a flasher installation. If an existing structure is damaged, it shall be repaired or replaced as directed with no additional payment. The new span and catenary installation shall not interfere with the operation of the existing traffic signal. Traffic shall be controlled at all times during the changeover when the existing traffic signal is turned off and the new signal is turned on. This changeover shall take place such that the interruption is limited to a minimum amount of time.

When directed, temporary stop signs shall be erected at the intersection. When no work is in progress, the intersection shall have at least two operating signal faces for each approach. When the new installations are completed, any existing signal equipment and materials including wood poles, steel poles, and cast-iron handhole rings and covers which have not been used in the new installation shall be carefully removed. Regardless of the right to materials found on the project, as set out in other sections of these specifications, these items shall be stored at a secure site and salvaged by the appropriate governmental agency. The Contractor shall be responsible for any damage or loss of this equipment and shall repair or replace the same with no additional payment.

All existing painted signal equipment to be reused, such as pedestals, bases, controller cabinets, signals heads, signal weatherheads, pipe arms, shall be cleaned and painted with two coats of highway yellow enamel. Aluminum poles and mast arms shall not be painted.

Existing concrete foundations, which have not been used in the new installation, shall be removed to a minimum of 100 mm (4 in.) below the adjacent grade. The openings shall be filled with concrete and the surface finished and broomed, if they are located in sidewalk areas. Otherwise, they shall be filled with acceptable material conforming with the surrounding area. Existing signal handholes to be removed, shall be filled after removing rings and covers, with B borrow with a minimum of 100 mm (4 in.) of concrete on top to bring it up to grade in a sidewalk area. Surfaces shall be finished and broomed. Otherwise, they shall be filled with acceptable material conforming with the surrounding area.

The signal controller timings will be provided and the Engineer shall be present when the signal intersection is to be placed in operation.

All electrical wiring terminations and splices; controller and cabinet set-up; and testing, review, and turn-on of all operational apparatus at each location shall be done by or in the presence of and under the responsible charge of an employee of the Contractor who holds a Level II Traffic Signal Electrician certification which has been granted by the International Municipal Signal Association. Supervision of non-electrical, traffic signal related construction work and traffic control shall be done by a person holding a Level I Work Zone Traffic Safety Specialist certification which has been granted by the

International Municipal Signal Association, or an equivalent certification approved by the Department.

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Before starting work, the Contractor shall provide the names of the Level II Traffic Signal Electricians and Level I Work Zone Traffic Safety Specialists who have been assigned to perform signal related work, and a photocopy of each such person's certification card. If the Level II Traffic Signal Electricians or Level I Work Zone Traffic Safety Specialists are dismissed from the work, all signal related work requiring such certified personnel on the project site shall cease until the names and photocopies of certification cards for replacement personnel are provided to the Engineer.

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Electrical work shall be executed in accordance with the requirements of the National Board of Fire Underwriters, the State Fire Marshal, and the power company which will furnish the electric service. The work shall be in accordance with any local regulations that may apply. The Department will arrange and provide for power service which the power company will bring to the point designated on the plans. Prior to the start of construction, the schedule of activities shall be coordinated with the power company and they shall be contacted again at least 14 days prior to the time the service work is to be completed.

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The Department will obtain permits from local officials, companies, or individuals for the use of poles, right-of-way, or other property incidental to the installation of traffic signal. Although entering into the contract implies permission and authority to cut into and push under pavement, sidewalks, and alleys, any damage to underground utilities or interruption of such service shall be the responsibility of the Contractor. The Contractor shall be in accordance with local regulations as well as 107.07. Protective devices shall be in accordance with 107.11 and 801.

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The location of signal heads, controllers, signal poles, signal cantilever structures, detector housing, disconnect hangers, and other installation items will be shown on the plans. However, a change in the location of an item may be ordered during the progress of the work. The work shall be completed as shown on the plans except for those changes specifically authorized in writing.

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805.04 Pole Installation. Metal poles shall be erected on concrete foundations and shall be reasonably plumb after installation of signal heads. The handhole side of the pole shall be at right angles to the direction of the mast arm or span, catenary, and tether. Signal cables shall be brought up inside the poles. Any steel pole, mast arm, or hardware not galvanized or painted with baked enamel shall be painted with two coats of rust inhibiting aluminum paint. Paint shall be applied in accordance with 619 with the exception that commercial blast cleaning of the steel will not be required. All rust, scale, and dirt shall be cleaned from the metal surface so that paint adheres to the surface.

The construction of concrete foundations shall be in accordance with 805.13. Wood poles shall be set a minimum of 2.1 m (7 ft) in the ground and raked 300 mm (12 in.).

805.05 Placing Signal Heads. Mast arm and span mounted signal heads shall have 5.2 m (17 ft) minimum and 5.8 m (19 ft) maximum clearance over the roadway unless there are visual obstructions which require lowering the signal head. A signal head over the roadway shall not have a clearance of less than 4.6 m (15 ft). Such signal heads shall be located over the intersection as shown on the plans. Such signal heads shall have a uniform clearance, which will be determined. Signal heads not mounted over a paved roadway, on the top or side of a pole, shall not be less than 3 m (10 feet) nor more than 4.6 m (15 ft) above the sidewalk or, if none, above the pavement grade at the center of the roadway. Signal faces shall be directed to the proper approach lane in each direction. Pedestrian signal faces shall be mounted with the bottom of the housing at not less than 2.1 m (7 ft) nor more than 3 m (10 ft) above the sidewalk. The pedestrian signal shall be in line with the pedestrian's vision at the appropriate crosswalk being used. Pedestrian push-buttons shall be mounted at a height of 1.1 to 1.2 m (3 1/2 to 4 ft) above the sidewalk as shown on the plans. A pedestrian actuated signal sign shall be mounted immediately above the push-button.

Signal heads shall be assembled and wired with one conductor, THW, stranded wire. Where splices are made, a 0.6 m (2 ft) minimum length of cable or wire in excess of that required for a continuous run shall be provided. Splices shall be twisted together and soldered or approved type connectors used. Each splice shall be completely insulated by wrapping with an approved tape and sealed with an approved electrical coating material. Splices shall be made in such manner that the connections are moisture proof. The cables coming out of the signal weatherhead shall be looped to form a drip loop. The drip loop shall be made so that the cables coming out of the weatherhead loop down below the elevation of the weatherhead to prevent water from following the cable into the weatherhead. If used, the splice indicated above shall be located in the top of the coils of cable forming the drip loop.

Signal heads shall not be installed until all other work has been completed. If it becomes necessary to mount signal heads for more than 2 h before the lights are to be turned on, the signal heads shall be hooded by placing sacks or similar cover over them so as to conceal them from traffic. Hooded signal heads are not permitted to be in place for more than five days. No signal head shall be left over night with the lights out unless it is hooded. Signal heads shall be securely mounted. The polycarbonate signal face shall be used only when securely supported on both ends of the assembly. In a span cable installation, a tether cable would satisfy this requirement.

805.06 Grounding. All signal supports, signal controller supports, and entrance switches shall be grounded in accordance with the applicable requirements of 807.12.

805.07 Wire and Cable Installations. All cable runs attached to utility poles shall have code clearance relative to utility cables. They shall be no less than 5.5 m (18 ft) above the ground level except over railroad tracks when a minimum of 8.2 m (27 ft) clearance shall be maintained. All cable runs shall be installed in continuous lengths without splices between terminals except when necessary at handholes, junction boxes, pole signal bases, and pedestal bases. The type of cable and the number of conductors as well as the gage shall be as shown on plans unless otherwise specified.

Cable rings shall be used to support the signal cable on the signal span cable. They shall be spaced 300 mm (12 in.) on center. Cable shall be pulled through the conduit to the terminal panel in the controller cabinet. Caution shall be used to prevent damage to the cable when it is being pulled through conduit.

Coded cable conductors shall be used throughout the installation. Cable conductors shall be tagged at all detector housing, handholes, pole signal bases, and controller cabinets. Tags shall consist of an aluminum blank of sufficient size to be stamped with not less than 5 mm (3/16 in.) high all upper case letters which identify the cables by their use and phase. The following are the uses which shall be indicated by the tags:

- (a) Power
- (b) Pedetrian Signals
- (c) Pedestrian Actuation
- (d) Signal-Phase Identification
- (e) Detection Loop Identification

Loop identification shall consist of the following:

Inside of the Detector Housing, the loop wires of each loop shall be tagged with, in _____, out _____, as shown on the plans.
Loop Number Loop Number

Inside of the Controller Cabinet, each lead-in cable shall be tagged within 150 mm (6 in.) of the terminal strip connection with: Lane designation, Phase Number, Loop Number, and when applicable with loop system number, and speed trap according with the plans.

Phase identification shall consist of the single number "1", "2", "3," etc., which corresponds to the phase diagram for the respective intersection. Tags shall be securely fastened to the cable with a non-corroding material. The tagging material and fastening shall be approved prior to proceeding with this work. The color coded wires shall be connected properly. The white wire shall be the common or ground. Wire used for all identical indications of any individual phase shall be color coded and, where possible, shall use red wire to connect red lenses, orange wire to connect yellow lenses, and green wire to connect green lenses. Signal heads shall be assembled and wired before installed. The testing of the loops shall be documented in the Loop Testing Table provided by the State.

805.08 Controller Cabinet, Signal Service, and Detector Housing Installation. The controller cabinet shall be mounted securely on a pole, pedestal, or concrete foundation. All cabinets on concrete foundations shall be installed with the anchor bolts inside. Controller cabinets on poles or pedestals shall be mounted at a height of 970 mm (38 in.) \pm 50 mm (2 in.). Pole mounted controller cabinets shall be fastened with two

230 stainless steel bands as shown in the plans. Signal cables and lead-in cable shall be run in conduit from the controller cabinet to the signal support base and to detector housing as indicated on the plans. Galvanized steel elbows shall be used on the detector housing as shown on the plans.

The Contractor shall wire the entrance switch and bring service cable up the riser and out the weatherhead and leave 1.2 m (4 ft) of cable outside the weatherhead. The utility company, at their option, may bring the service cables to the load side of the entrance switch. Meter bases, if required, shall be obtained from the power company and any service connection or miscellaneous charges shall be assumed by the Contractor.

240 A minimum of 300 mm (12 in.) and a maximum of 450 mm (18 in.) of loop wire duct will be permitted in the detector housing for each loop lead. High-early-strength concrete in accordance with 305.06(a), shall be used in the installation of detector housings, except where a portion of the road is closed or where there is no vehicular traffic, then class A concrete may be used. The concrete shall be placed flush with existing surface and shall be covered with a steel plate during the setting time.

805.09 Loop Wire Detector Installation. This work shall consist of placement and testing of loop wire detectors in accordance with the installation details shown on the plans.

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MATERIALS

Loop wire shall be in accordance with 913.15(f)4e(2). Loop detector sealant shall be in accordance with 913.15(f)4e(3).

Loops shall be of a regular octagon shape with side of 0.75 m (2.5 ft) in length. An outline shall be laid out and painted where the loops shall be sawed. The loop locations shall be subject to the review and approval of the District Traffic Engineer. The District Traffic Engineer shall be notified 48 h prior to such field review.

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The slots shall be saw-cut as shown on the plans. Slots shall be thoroughly cleaned and dried before the installation of loop wires. The specified number of turns shall be placed in the slot and gently tamped with a blunt non-metallic tool. A sash cord or backer rod shall be placed above the wire after tamping. The number, size, arrangement, and locations of loops shall be as shown on the plans. Loop spacing shall be adjusted to avoid pavement joints. Loop wire shall be pressed into the saw slot with a blunt nonmetallic tool. Loop wire shall only be bent at angles of 120 degrees or greater. All loops shall be wired clockwise as viewed from above. Loops shall be wired with four turns and in a series unless otherwise specified. Joints shall be overlapped such that the saw cut at the corner is full depth. The sealant shall be poured into the saw cut making a water tight seal. The splice of the loop wire and lead-in cable shall be soldered and waterproofed at the detector housing. Waterproofing shall consist of the use of heat shrink tubing which has an internal coating sealant material. The heat shrink tubing shall not be heated by means of a direct flame tool. Loop wire and lead-in cable shall be tagged according to the plans and 805.07. The black lead-in wire shall be spliced to the loop wire which goes

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back to the field. Such wire shall be tagged as "Out/Loop (No.)". The white lead-in wire shall be spliced to the loop wire which comes in from the field. Such wire shall be tagged as "In/Loop (No.)".

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TESTING

The Contractor shall meter all new loop wire detectors or a new bank of loop wire detectors by means of instruments capable of measuring electrical values for installed loop wires and lead-in cables. The instruments shall measure inductance in microhenries, resistance in ohms, induced A.C. voltage in volts, and leakage resistance in megohms. All measuring tests shall be performed at the detector housing before the loop wire is spliced to the lead-in cable, and at the cabinet after the loop wire is spliced to the lead-in cable.

290 **(a) Megohm Test Before Splice is Made at Detector Housing for Loop Wire.** One of the megohm probes shall be connected to ground and the other probe shall be connected to the "in" or "out" loop wire. The remaining loop wire shall be isolated. The test shall then be performed.

(b) Megohm Test Before Splice is Made at Detector Housing for Lead-in Cable. The two wires of the lead-in cable at the cabinet shall be twisted together and taped. The shield of the lead-in cable shall be grounded in the cabinet. At the detector housing, one megohm probe shall be connected to ground and the other probe shall be connected to one of the lead-in wires. The remaining lead-in wire shall be isolated. The test shall then be performed.

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(c) Megohm Test After Splice is Completed at Cabinet. This test shall be performed after the splice at the detector housing is completed. A water solution of 15 ml (one tablespoon) of baking soda per 0.5 L (pint) of water shall be placed in a metal container. The metal container shall be grounded and the splice shall be fully submerged in the solution for 2 min. With the splice submerged, the megohm test shall be performed at the cabinet on the end of the lead-in cable.

310 **(d) Vehicle Simulator Test.** This test shall be performed after all other tests are completed and after all connections have been made at the controller in the cabinet. This test shall be performed by dragging a test vehicle across the loops using a non-conducting string. The test vehicle shall be fabricated with an 2.4 m (8 ft) length of No. 6 bare copper wire formed into a circle. The two ends shall then be electrically spliced. The detector unit amplifier shall record a call as the test vehicle is dragged across the loop. It shall cancel the call as the test vehicle leaves the loop.

320 **(e) Acceptance Criteria.** The Contractor shall record all test readings, in triplicate, on tabular forms provided by the Department or by copying the one included elsewhere herein. The Contractor shall complete, sign, and date the forms before submitting them to the District Traffic Engineer. The District Traffic Engineer will use these forms for recording the Department's readings on the corresponding space provided.

In order for the loop detector installation to be accepted, the electrical values shall be as follows:

1. Inductance shall be between 80 and 800 μ H. Inductance shall be determined by means of digital readout meter which drives the field loop system.
2. Resistance shall be less than or equal to 8 ohms.
3. Voltage shall be less than or equal to 3 V.
4. Induced A.C. voltage and leadage resistance shall be greater than 100 megohms.

Loop wire and/or lead-in cable failing to meet this requirement shall be replaced at no cost to the State.

805.10 Magnetometer and Microloop Detectors. Before installation of Magnetometer or Microloop probes the Contractor shall confirm the adequacy of the magnetic field intensity, to be sure that the range is suitable for their operation. Arrangement of probes shall be located at maximum distance from steel support under bridges. Probes shall be installed with their long dimension vertical, and with the cable end at the top. Probes shall be firmly supported, so the lateral and vertical motion is restricted. Probes shall be connected in series. The splice shall be soldered by means of hot iron, or pouring or dripping without flames, with rosin core solder and shall be insulated and waterproofed in accordance with the manufacturer's specifications.

805.11 Steel Conduit. Conduit shall be installed to a depth of no less than 0.6 m (2 ft) or more than 1.5 m (5 ft) below the finished grade unless otherwise specified or approved. Pockets or traps where moisture might accumulate shall be avoided. Conduit shall be placed under existing pavement by approved jacking or drilling methods. Pavement shall not be disturbed without permission. If permission is granted, cuts in pavement areas shall be no greater than 600 mm (24 in.) wide. All cuts in the pavement and sidewalk areas shall be sawed. Sidewalk removal and replacement shall be to the nearest tooled joint. Jacking and drilling pits shall be kept at least 0.6 m (2 ft) clear of the edge of any type of pavement or paved shoulder. Excessive use of water that may cause undermining of the pavement shall be avoided. Continuous conduit runs shall not exceed 76 m (250 ft) in length, unless otherwise indicated on the plans.

Expansion fittings as detailed on structure plans shall be installed where conduit crosses an expansion joint in the structure. Where it is deemed inadvisable to install expansion fittings in closely confined areas, the installation of approved flexible tubing may be permitted. Such expansion joints or tubing shall be the same size as the conduit. Any existing underground conduit to be incorporated into a new signal installation shall be cleaned with a mandrel and blown out with compressed air before cable is drawn into pipe. All new conduit runs shall be cleaned and swabbed before cables are installed. All conduit ends shall be capped and shall remain capped until the Contractor is ready to pull cable into the conduit, at which time the caps shall be removed and conduit bushings

370 placed on each end to protect the cable. The inside surface of the conduit shall be kept
clean. Conduit to be installed, indicated on the plans for future use of signal cables, shall be
left in place with a pull cord on it's entire length.

Larger size conduit may be used with no additional payment, but when it is used, it
shall be for the entire length of the run from outlet to outlet. Conduit runs as shown on the
plans are for bidding purposes only and may be changed, with permission, to avoid
underground obstructions. A change order may be authorized if the conduit runs can be
made on the opposite side of the street to that shown on the plans in order to avoid
obstruction and traffic inconvenience or to avoid unnecessary tearing up of existing
380 pavement.

805.12 PVC Conduit. The method of installing PVC conduit under-ground shall
be the same as for steel conduit where applicable except trenches for the conduit shall be
backfilled with 50 mm (2 in.) of sand before the conduit is placed in the trench. Materials
excavated may be used for backfill, if approved. If the engineer deems it necessary,
approved B borrow shall be placed over the conduit to a depth of 300 mm (12 in.) and the
remainder of the trench shall be filled with excavated material.

805.13 Foundations. Foundations for traffic signal poles, cabinets, and pedestals
390 of the type specified shall be constructed, or existing M foundations shall be modified, as
shown on the plans or as directed. Pedestal bases shall be plumb and firmly attached to the
anchor bolts either by using leveling nuts or shims if top of the foundation is not level.
Grouting shall be used when necessary to fill any gap between pedestal base and foundation.
Pipe pedestals shall be screwed tightly into the bases and secured with a stainless steel pin.
Power and signal cables shall then be pulled from the base into the cabinet. Curing of
concrete shall be in accordance with 702.21.

During excavation of the foundation, all material shall be removed to the full depth
as shown on the plans, except if class X material is encountered, the work shall be
400 performed in accordance with 206.02(b).

805.14 Final Clean-Up. When the installation is completed, all disturbed portions
of sidewalk, pavement, shoulders, driveways, sod, etc., shall be cleaned and any excess
excavation or other materials shall be disposed. All cutting in the sidewalk and pavement
areas shall be done with a saw. Sidewalk removal and replacement shall be to the nearest
tool joint. Unless otherwise direction, cuts in pavement areas shall be no greater than
300 mm (12 in.) in width.

805.15 Method of Measurement. Traffic signal head, pedestrian signal head,
410 pedestrian push button, controller cabinet foundation, M foundation modified to P-1
foundation, signal steel strain pole, signal wood pole, signal cantilever structure, signal
support foundation, signal service, disconnect hanger, magnetometer detector, microloop
detector, loop detector delay amplifier, signal handhole, signal detector housing, span
catenary and tether, and span catenary for flasher will be measured by the number of units
installed.

Conduit of the type specified will be measured by the meter (linear foot) from outside to outside of foundations. Signal cable and signal interconnect cable will be measured by the meter (linear foot).

420

The accepted quantities for payment for electrical signal or loop lead-in cable will be the quantities shown in the Schedule of Pay Items. Such quantities may be corrected if they are in error by more than 25%.

Saw cut for roadway loop detector and sealant will be measured by the meter (linear foot) for the full depth of slot cut in the pavement as shown on the plans or as directed.

430 If class X material is encountered during foundation excavation, measurement will be made in accordance with 206.10.

Traffic signal installation or modernization, flasher installation or modernization, miscellaneous equipment for traffic signals, and final cleanup in accordance with 805.14 will not be measured for payment.

805.16 Basis of Payment. Traffic signal installation, flasher installation, traffic signal modernization, and flasher modernization, all of the type and the location number specified, will be paid for at a contract lump sum price.

440 If specified as pay items, traffic signal controller and cabinet, traffic signal head, pedestrian signal head, pedestrian push button, controller cabinet foundation, M foundation modified to P-1 foundation, signal steel strain pole, signal wood pole, signal cantilever structure, signal support foundation, signal pedestals, signal service, disconnect hanger, magnetometer detector, microloop detector, loop detector delay amplifier, signal handhole, signal detector housing, span catenary and tether, and span catenary for flasher will be paid for at the contract unit price per each. Conduit of the type specified, signal cable, interconnect cable, electrical signal cable, loop lead-in cable, and saw cut for roadway loop detector and sealant will be paid for at the contract unit price per meter (linear foot).

450 Class X excavation will be paid for in accordance with 206.11.

Miscellaneous equipment for traffic signals will be paid for at a contract lump sum price.

Payment will be made under:

Metric Pay Item (English Pay Item Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol)	
	Metric Pay Unit Symbol (English Pay Unit Symbol)	
Controller and Cabinet, _____, _____ Phase	type	no. EACH
Controller and Cabinet, Flasher, _____	type	EACH

	Controller Cabinet Foundation, _____	EACH
	type	
	Controller Cabinet Foundation, M, Modify to P-1	EACH
	Disconnect Hanger	EACH
470	Flasher Installation, Location No. _____	LS
	Flasher Modernization, Location No. _____	LS
	Handhole, Signal	EACH
	Loop Detector Delay Amplifier, _____ Channel	EACH
	no.	
	Magnetometer Detector	EACH
	Microloop Detector	EACH
	Miscellaneous Equipment for Traffic Signals	LS
	Pedestrian Push Button	EACH
	Pedestrian Signal Head, _____, _____	EACH
	type lens size	
480	Saw Cut for Roadway Loop and Sealant	m (LFT)
	Signal Cable, _____, No. _____ Copper, _____C/_____	m (LFT)
	type no. conductors/size	
	Signal Cantilever Structure, Mast Arm _____ m	EACH
	length	
	(Signal Cantilever Structure, Mast Arm _____ ft.	EACH)
	length	
	Signal Detector Housing	EACH
	Signal Interconnect Cable, _____, No. _____ Copper, _____C/_____	m (LFT)
	type no. conductors/size	
490	Signal Pedestal, _____ m	EACH
	length	
	(Signal Pedestal, _____ ft	EACH)
	Signal Pole, Wood, _____, _____ m	EACH
	class length	
	(Signal Pole, Wood, _____, _____ ft.	EACH)
	class length	
	Signal Service	EACH
	Signal Strain Pole, Steel, _____ m	EACH
	length	
500	(Signal Strain Pole, Steel, _____ ft.	EACH)
	length	
	Signal Support Foundation, _____ mm x _____ mm x _____ mm	EACH
	(Signal Support Foundation, _____ in. x _____ in. x _____ in.	EACH)
	Span and Catenary for Flasher	EACH
	Span, Catenary, and Tether	EACH
	Traffic Signal Head, _____ Way, _____ Section, _____	EACH
	no. no. lens sizes & colors	
	Traffic Signal Installation, _____, Location No. _____	LS
	type	
510	Traffic Signal Modernization, _____, Location No. _____	LS
	type	

The costs of all wiring, hardware, anchor bolts, and associated equipment required to operate the intersections shall be included in the cost of controller and cabinet, flasher.

520 The costs of signal face hook-up wire, pole plates and arms for side mounts, mid-mast arm mount, pipe arms, signal brackets, visors, louvers, bulbs, span hanger, backplates, balance adjuster, weatherhead, and all additional hardware required to assemble a combination of signal faces as shown on the plans shall be included in the costs of traffic signal head or pedestrian signal head.

The costs of the push button, pedestrian actuated signal sign, and all hardware required to complete the installation shall be included in the cost of pedestrian push button.

The costs of concrete, conduits, grounding bushings, ground rod, ground wire, drainage, and all hardware required to complete the installation shall be included in the cost of controller cabinet foundation.

530 The costs of the base plate, metal skirt base plate, anchor bolts, handhole and cover grounding lug, 50 mm (2 in.) pipe cable entrance, J hook, and top cover as shown on the plans shall be included in the cost of signal strain pole, steel.

The costs of downguys, anchor rods, downguy guards, and hub-eyes as shown on the plans, and all hardware required to complete the installation shall be included in the cost of signal pole, wood.

540 The cost of all hardware including the metal skirt base plate, where necessary, to complete the installation as shown on the plans shall be included in the cost of signal cantilever structure.

The costs of concrete, reinforcing steel, conduits, ground rod, ground wire, grounding bushings, and all hardware required to complete the installation shall be included in the cost of signal support foundation.

The costs of the pedestal metal base, pedestal pole, pole cap when necessary, anchor bolts, and all hardware required to complete the installation shall be included in the cost of signal pedestal.

550 The costs of weatherhead, 25 mm (1 in.) conduit riser, entrance switch, 25 mm to 50 mm (1 in. to 2 in.) conduit reducer, ground rod, ground wire, and all hardware required to complete the installation, including the meter base when required and supplied by the utility company shall be included in the cost of signal service.

The costs of the detector unit, lead-in cable, and all work necessary for proper installation shall be included in the cost of magnetometer detector or microloop detector.

The costs of the slot cut on the pavement, sash cord, backer rod, loop sealant, and all testing in accordance with 805.09 shall be included in the cost of saw cut for roadway loop and sealant.

560

The costs of all work and hardware required to properly install overhead or underground signal cable as shown on the plans or as directed shall be included in the cost of signal cable and signal interconnect cable.

The costs of the independent shelf mount unit or card-rack unit, and power module shall be included in the cost of loop detector delay amplifier.

570 The costs of concrete reinforcing pipe, ring and cover, eye bolts, hardware, handhole bottom, and aggregate under the handhole bottom as shown on the plans shall be included in the cost of handhole, signal.

The costs of aluminum casting, enclosure concrete, steel conduit and elbow, and all hardware required to complete the installation shall be included in the cost of signal detector housing.

580 The costs of steel pole bands or straight eye bolts, span, catenary, and tether of wire rope cables, cable rings, type A support cable, wire rope clips, safety cable, thimble, service sleeve, and all hardware required to complete the installation as shown on the plans shall be included in the costs of span, catenary, and tether for signal, or span and catenary for flasher.

The costs of excavation, backfill, final cleanup in accordance with 805.14, and necessary incidentals shall be included in the costs of the pay items.

SECTION 806 -- TEMPORARY TRAFFIC SIGNALS

806.01 Description. This work shall consist of furnishing and installing temporary traffic signals in accordance with these specifications and in reasonably close conformance with the lines, grades, and locations shown on the plans or as directed.

MATERIALS

806.02 Materials. Materials shall be in accordance with the following:

10

Conduit and Fittings	913.15(j)
Controller Cabinet, Type G	913.15(a)7
Messenger Span and Wire Cable	913.15(f)
Pre-timed, Solid State Digital Controller.....	913.15(a)5
Signal Head Components	913.15(d)
Traffic Actuated Solid State Digital Controller.....	913.15(a)6
Wood Strain Pole	913.15(e)2

20 Except as noted on the plans, all materials not furnished by the Department shall be the property of the Contractor after work is completed and the equipment is removed.

The traffic signal equipment shall be as specified, but may be either new or used. Used equipment shall be in excellent working condition and must be approved for use in the contract.

CONSTRUCTION REQUIREMENTS

30 **806.03 General Requirements.** This work shall be in accordance with the MUTCD. All signs, barriers, and barricades shall be furnished and maintained in accordance with the plans or as directed. All traffic equipment shall be in good working condition.

Electrical work shall be performed in accordance with the requirements of the National Electric Code, National Board of Fire Underwriters, the State Fire Marshal, and the power company which will furnish the electric service. The work shall conform to local regulations that may apply. Arrangements for service connection shall be made with the power company prior to the start of construction and the schedule of activities shall be coordinated with the power company.

40 Two signal heads shall be displayed for each approach. Signals shall be displayed overhead on a span, catenary, and tether utilizing an aircraft cable, unless otherwise directed.

Permits shall be obtained from local officials, companies, or individuals for the use of poles, right-of-way, or other property incidental to the installation of temporary traffic signals. Although entering into the contract implies permission and authority to install conduit under pavement, sidewalks, and alleys, any damage to underground utilities or interruption of such service shall be the responsibility of the Contractor. Protective devices shall be in accordance with 107.11 and 801.

50 The location and spacing of signals will be determined prior to commencing work. Signal timing will be determined by the Engineer.

Trained personnel who are available 24 h a day shall be provided to maintain the traffic signal equipment.

60 **806.04 Pole Installation.** Temporary wood poles shall be set a minimum of 2.1 m (7 ft) in the ground and raked 300 mm (12 in.) with down guys. The poles shall be located as directed.

806.05 Signal Heads. The signal head shall be die-cast aluminum. The span mounted signal heads shall have a 5.2 m (17 ft) minimum and a 5.8 m (19 ft) maximum clearance over the roadway unless there are visual obstructions which require lowering the signal head. A signal head over the roadway shall not have a clearance of less than 4.6 m (15 ft).

Signal heads shall be assembled and wired with one conductor, THW, stranded wire. The cables coming out of the signal weatherhead shall be looped to form a drip loop. The drip loop shall be made so the cables coming out of the weatherhead will loop

70 down below the elevation of the weatherhead to prevent water from following the wire into the weatherhead.

Signal heads shall not be installed until all other traffic control work has been completed. Signal heads mounted for more than 2 h prior to turn-on shall be completely hooded with sacks or similar cover. No signal head shall be left over night with the lights out unless it is completely hooded. Signal heads shall be securely mounted.

The certification of the signal head shall be dated within 12 months prior to the date of purchase.

80

806.06 Grounding. All signal supports, signal controller supports, and entrance switches shall be grounded in accordance with 913.15(f)4f and 913.15(g). Ground wire shall be solid copper.

90

806.07 Wire and Cable Installations. All cable runs contacting utility poles shall be required to have code clearance relative to utility lines. They shall be no less than 5.5 m (18 ft) above the ground level except that over railroad tracks when a minimum of 8.2 m (27 ft) clearance shall be maintained. All cable runs shall be installed in continuous lengths without splices between terminals except at junction boxes. The type of cable and the number of conductors as well as the gage shall be as specified.

Signal cable may be extended across bridges through steel or PVC conduit which shall be attached to the underside of the coping. Type and spacing of clamps shall be approved prior to installation.

806.08 Controller. The controller shall be solid state digital. When detection is required, the controller shall be traffic actuated solid state, digital. The control unit shall be wired for a four phase operation, unless otherwise specified.

100

806.09 Controller Cabinet, Signal Service, and Detector Housing Installation. The controller cabinet shall be as specified. Unless otherwise specified, the cabinet shall be securely mounted on a pole at a height of 970 mm (38 in.) \pm 50 mm (2 in.) and shall be fastened with two stainless steel bands. Multiple conductor signal cables shall be run in conduit from the controller cabinet to the signal pole weatherhead and to the detectors as indicated on the plans. Connections with detectors shall be made as shown on the plans inside the detector housing. Galvanized steel elbows shall be used on the detector housing.

110

All equipment necessary for the supply of service shall be furnished and installed. This shall include the weatherhead, riser, entrance switch, 25 mm (1 in.) conduit, 50 mm (2 in.) to 25 mm (1 in.) conduit reducer, ground rod, and ground wire. Meter bases, if required, shall be obtained from the power company and any service connection or miscellaneous charges shall be paid by the Contractor. The entrance switch shall be wired and the service cable brought up the riser and out the weatherhead. There shall be 1.2 m (4 ft) of cable left outside the weatherhead. The utility company, at their option, may bring the service cables to the load side of the entrance switch.

120 **806.10 Loop Detector Installation.** Loop detectors, if required, shall be installed as shown in the plans or as otherwise directed. Only specified wire and sealant shall be used in the installation of loops for detectors. Installation shall be in accordance with 805.09.

806.11 Conduit. Conduit may be steel or PVC. It shall be installed as shown on the plans. Flexible conduit will be an acceptable alternate for use ground rod entries, and magnetometer or microloop installations.

130 **806.12 Final Clean-Up.** When the installation is completed, all portions of sidewalk, pavement, shoulders, driveways, sod, and other areas which have been disturbed shall be cleaned, repaired or replaced as directed. Any excess excavation or other materials shall be removed.

806.13 Method of Measurement. Temporary traffic signals will not be measured for payment unless otherwise provided.

806.14 Basis of Payment. The accepted temporary traffic signal, complete in place and later removed as specified will be paid for at the contract unit price for lump sum.

 Payment will be made under:

140	<table><tr><th>Pay Item</th><th>Pay Unit</th></tr><tr><td>Temporary Traffic Signal.....</td><td>LS</td></tr><tr><td>Temporary Traffic Signal with Loop Detectors.....</td><td>LS</td></tr></table>	Pay Item	Pay Unit	Temporary Traffic Signal.....	LS	Temporary Traffic Signal with Loop Detectors.....	LS
Pay Item	Pay Unit						
Temporary Traffic Signal.....	LS						
Temporary Traffic Signal with Loop Detectors.....	LS						

SECTION 807 -- HIGHWAY ILLUMINATION

807.01 Description. This work shall consist of installing wire, cable, conduit, lighting standards, luminaires, lamps, and incidental materials in accordance with these specifications and in reasonably close conformance with the lines, grades, and locations shown on the plans or as directed.

10 Lighting installations shall be in accordance with the National Electrical Code and the National Safety Code.

807.02 Maintenance of Highway Illumination. Existing highway illumination shall be maintained on all projects unless discontinuance of the highway illumination is specifically permitted.

MATERIALS

807.03 Materials. Materials shall be in accordance with the following:

20	<table><tr><td>Aggregate (stone) size No. 53</td><td>904.02</td></tr><tr><td>Castings for Handholes.....</td><td>913.15(h)</td></tr><tr><td>Concrete, Class A.....</td><td>702</td></tr></table>	Aggregate (stone) size No. 53	904.02	Castings for Handholes.....	913.15(h)	Concrete, Class A.....	702
Aggregate (stone) size No. 53	904.02						
Castings for Handholes.....	913.15(h)						
Concrete, Class A.....	702						

Conduit	913.15(j)
Highway Illumination Materials	913.11
Line Hardware.....	913.15(f)
Paint.....	909
Reinforced Concrete Pipe.....	906.02
Reinforcing Steel.....	910.01

30 Manufacturers' descriptive and technical literature for major items shall be submitted for approval. Where it is normal trade practice to furnish a warranty, a warranty shall be furnished on all major items such as luminaires, lamps, poles, brackets, cable-duct, wire and cable, fuse connectors, and ballasts. The effective date of the warranty shall commence on the date of final acceptance. These items shall bear the seal of approval of the UL.

All flexible conduit shall be galvanized steel, polyvinyl jacketed, and watertight.

CONSTRUCTION REQUIREMENTS

40 **807.04 Excavation.** All excavation for the roadway lighting installation shall be performed in accordance with the dimensions, elevations, and grades shown on the plans or as directed. If class X material is encountered, foundation excavation shall be completed in accordance with 206.

50 (a) **Trench Excavation.** Excavation may be accomplished either manually or with mechanical trenching equipment. The blades of road patrols or graders shall not be used to excavate the trenches. The depth of trenches shall be a minimum of 0.6 m (2 ft). Walls of trenches for cable-duct or conduit shall be essentially vertical. The bottoms of trenches shall be smooth and free from aggregate larger than 13 mm (1/2 in.). Bracing, shoring, and sheathing shall be provided as necessary. If the excavation, through accident or otherwise, is below the required level, the excess excavated area shall be refilled in a satisfactory manner with no additional payment. The accumulation of water in excavated areas shall be prevented by the use of pumps or other approved means. When rocks or other materials which might damage the cable-duct or conduit are encountered, the excavation shall be extended to a depth of at least 700 mm (27 in.) and backfilled with a 75 mm (3 in.) compacted layer of sand or earth containing no particles that would be retained on a 6.3 mm (1/4 in.) sieve. No extra payment will be made for this additional excavation or backfill.

60 (b) **Foundation Excavation.** If possible, excavation for concrete foundations shall be accomplished by means of drilling with an auger of sufficient size to admit the width of the foundation. Work shall be so scheduled that all open excavations are poured with concrete during the work day they are dug. No excavations shall remain open over night or over a weekend or holiday. Accumulated water shall be removed from the excavation before concrete is poured. If class X material is encountered, foundation excavation shall be completed in accordance with 206.02(b).

(c) **Landscape Replacement.** Where roadside shrub plantings interfere with the location of illumination installations, the plantings shall be reset at other locations and at such times as directed, all in accordance with 622. The cost of this work will not be paid for directly, but shall be included in the costs of other pay items.

All slopes for foundation grading shall be sodded. Sod shall be placed in accordance with 621.

807.05 Backfilling. Wherever practicable, all suitable materials removed from the excavated areas shall be used in refilling cable-duct and conduit trenches. No excavated materials shall be wasted without authorization. Materials authorized to be wasted shall be disposed of as approved. Backfill for trenches shall be placed in layers not to exceed 150 mm (6 in.), loose measurement. The first layer shall be sand or earth containing no particles or lumps that would be retained on a 6.3 mm (1/4 in.) sieve. The second layer shall contain no particles or lumps that would be retained on a 25 mm (1 in.) sieve. Subsequent layers shall contain no particles or lumps that would be retained on a 75 mm (3 in.) sieve. The second layer and each subsequent layer shall be compacted with pneumatic hand tamps to the satisfaction of the Engineer to prevent any future settlement of the backfilled area. Backfilling of cable-duct and conduit trenches around lighting standard foundations, handholes, manholes, and other structures shall be in accordance with the applicable provisions of 211. Finish grading of earthwork shall be accomplished in a satisfactory manner.

807.06 Placing Conduit. Conduit shall be placed as shown on the plans and in accordance with applicable provisions of 805.11. Conduit shall be of a size to readily permit the passage of the cable-duct being used.

Conduit installed under pavement shall extend a minimum of 0.6 m (2 ft) beyond the edge of the paved surface or improved shoulder. The ends of such conduit shall terminate a nominal 0.6 m (2 ft) below the ground surface. The ends shall be pitched so as to provide a positive drain to the surrounding soil. The ends shall be protected by threaded cap fittings until the time of installation of cable or cable-duct. Threaded bushing fittings shall be used on all ends before cable installation.

Conduits installed in bridge railing concrete sections shall terminate a minimum of 0.6 m (2 ft) beyond the end of the bridge railing outside of the paved surface and a minimum of 0.6 m (2 ft) under the ground surface. Existing conduit shall be extended as necessary to satisfy these requirements.

Hot-dipped galvanized, malleable pipe straps and spacers shall be used to attach conduit to bridge structures. Galvanized steel conduit hangers or pipe clamps will not be permitted. Pipe straps of the proper size shall be installed 1.2 m (4 ft) center to center along the conduit. When fastening pipe straps to concrete, a 9.5 mm (3/8 in.) by 63 mm (2 1/2 in.) galvanized steel lag screw, with an approved sleeve, shall be used; however, other approved expansion anchors may be used. The pipe strap and spacer shall be bolted to the steel beams.

Conduit for service supply shall be mounted on a service pole, either company or State owned, near the right-of-way line. For simple supply circuits, one straight, continuous, conduit riser shall be used. The top end shall terminate with a weatherhead device, and the lower end shall terminate at least 0.6 m (2 ft) below ground level with a threaded grounding bushing fitting. Unless otherwise directed, the weatherhead shall be 7.3 m (24 ft) above the ground. However, the actual elevation of the weatherhead shall meet the requirements of the utility concerned.

807.07 Connections in Base of Lighting Standards. Conductors shall be electrically bonded to each other, as required to satisfy circuit requirements, by means of compression type fittings of the style and type shown on the plans. Inhibitor compound shall be used on each compression connection. Conductor identification shall be maintained by connecting like color connectors.

A multiple conductor compression fitting shall be used to connect supply conductors and an insulating link used to provide an extension as shown on the plans. These fittings shall be covered with snap-on fiber or plastic covers designed to protect them from electrical contact. Taping will not be permitted. The bare extension of the supply conductor from the multiple fitting to the insulation link shall be no longer than necessary to admit the application of the snap-on cover for the multiple fitting.

The pole circuits shall be connected by means of easily separated, single conductor connector kits. The connector kit on the "hot" side of the pole circuit shall be fused. The connector kit for the neutral side shall not be fused. Fuses shall be of the "KTK" series with a rated capacity three times the operating amperage of the luminaire. If the required capacity is not a standard size, the next larger size fuse shall be used.

The connector kit on the "hot" side of the pole circuit shall have the following features:

- (a) a line side and load side housing made of plastic or water resisting synthetic rubber suitable for direct burial in the ground or installation in sunlight;
- (b) a water seal between the two housings;
- (c) each housing permanently marked "Line Side" or "Load Side";
- (d) a spring loaded, 90% minimum conductivity, contact suitable for gripping the "KTK" cartridge fuse in each housing. These contacts shall be fully annealed;
- (e) an interior arrangement for each housing that will adequately receive and rigidly maintain the fuse contacts;
- (f) a terminal on each housing designed for a crimp type connection to the conductor that securely retains the conductor in the proper position;

- (g) a water seal between the conductor and the housing;
- (h) a disconnecting means that shall retain the fuse on the load side when disconnected and keep the conductive parts of the line side inaccessible; and
- (i) sufficient silicone compound provided and used to lubricate the metal parts and the rubber housings or boots for easy assembly.

170 The neutral side connector kit shall be similar in all respects to that described for the hot side except that a dummy fuse shall be used for the purpose of completing the electrical circuit. The bayonet disconnect feature of the connector kits shall be part of the load side of both the neutral side and the hot side conductors. The line side shall have a socket to receive the bayonet. These kits shall be installed in the pole circuit between the luminaire terminals and the compression connection to the underground distribution circuit as shown on the plans. A separate insulated conductor shall be used to connect the neutral of the underground distribution circuit and the neutral of the pole circuit to the ground lug in the pole base from the point at which both neutrals are connected together by a compression connection. The bayonet disconnect features from the neutral side and the hot side connector kits as cited above shall be included in the sign structure circuitry when
180 luminaires are installed on the sign structures. Consecutive roadway luminaires in a circuit shall be alternately connected to opposite load conductors R or B as specified in the plans to balance the load. Sign luminaires on individual structures shall be similarly connected.

807.08 Placing Wire and Cable.

(a) **Underground Through Cable-duct.** All underground distribution conductors shall be continuous runs between splice points. Unless otherwise authorized, splice points shall be inside the bases of lighting standards, inside handholes, in service distribution boxes, at point of connection to power supply in switch boxes, or in junction
190 boxes. All splices shall be made with the proper connector in accordance with 807.06.

1. **Cable-duct.** Cable-duct shall be placed either in a trench or plowed into place. Cable-duct shall be installed without sharp bends or kinks and in straight runs so as to permit withdrawal of a conductor and the installation of a new conductor without additional excavation or backfill.

Plowed cable-duct shall be installed at a minimum depth of 0.6 m (2 ft) in a single cavity gored into the earth by a vibrating plow blade. The equipment used for plowing the cable-duct shall be designed specifically for that purpose with the power and versatility to
200 easily and accurately bury the various sizes of cable-duct under all normal soil conditions. This equipment shall place the cable-duct without twisting, kinking, or damaging it in any way. Dragging or pulling the cable-duct from the start of the trenching operation will not be permitted. Where two ducts are to be installed parallel to each other, the distance between them shall be no less than 300 mm (12 in.) nor more than 600 mm (24 in.).

The plastic duct of the cable-duct shall be terminated 100 mm (4 in.) above the top of foundations or 100 mm (4 in.) inside handholes with sufficient excess conductors as directed. All terminations of this plastic duct shall be beveled free from any sharp edges or burrs. Insulation of the electrical conductor shall not be damaged when cutting the duct.

210

2. Cable Markers. The location of underground conduits or cable-ducts shall be marked with cable markers. The marker shall be placed at all changes in direction, where the underground distribution circuit is split, and at a maximum of 122 m (400 ft) intervals on straight runs. Cable markers shall be a slab of concrete 0.6 m (2 ft) square by 100 mm (4 in.) thick, with the word "Cable" die impressed into the surface of the marker, a minimum depth of 10 mm (3/8 in.) with letters a minimum of 50 mm (2 in.) high. Arrows showing the direction of the cable shall be die impressed or sawcut a minimum depth of 10 mm (3/8 in.) into the marker surface.

220

Curing of the concrete shall be in accordance with 702.21. The cable marker shall have a smooth metal trowel finish without scaling.

(b) Underground Through Conduit. The underground distribution circuit shall be protected by galvanized steel conduit when installed under pavement, in road shoulders, or elsewhere as shown on the plans or as directed.

230

1. Cable-duct. Cable-duct shall be pulled through the entire length of galvanized steel conduit if at all possible. If this is not possible, written authorization shall be obtained to permit the duct to be cut away and the conductors installed in the conduit with a minimum of 0.6 m (2 ft) of duct extended into the conduit. Where so authorized, the plastic duct shall be terminated in the proper transition fitting attached to the end of the conduit and each conductor of the cable-duct assembly shall continue undamaged and uninterrupted through the galvanized steel conduit to the other end of the conduit where a transition to the cable-duct shall be used again and the cable-duct shall continue uninterrupted to the next designated splice point. All transitions from galvanized steel conduit to cable-duct shall be accomplished with the proper adapter. This adapter shall provide a durable, watertight transition that has a smooth uniform interior.

240

2. Cable Markers. Cable markers shall be in accordance with 807.07(a)2.

(c) In Conduit Risers. Cable-duct shall enter the bottom of the conduit riser with a sweeping radius bend and continue up the riser to within 75 mm (3 in.) of the top of the conduit riser. At this point the plastic duct shall be terminated and the conductors shall continue uninterrupted and undamaged into the service cabinet, underpass switchbox, or through the weatherhead with sufficient excess to make the required connections.

250

(d) Through Conduit in Bridge Coping. Where a cable-duct underground distribution circuit is run through conduit installed in bridge coping, the duct shall be cut away and the conductors shall be installed in the conduit with at least 0.6 m (2 ft) of duct extended into the conduit. The conductors, through this transition, shall be continuous between authorized splice points. Where more than one lighting standard is to be installed

on the same side of the bridge structure and connected to the same distribution circuit, the cables pulled between these lighting standards shall be of the same type and size used in the cable-duct underground distribution circuit.

(e) **Aerial Cable.** Aerial cable for overhead distribution circuits shall be supported and terminated as shown on the plans. The aerial cable shall have a sag of no more than 5% of the distance between lighting poles except where slack spans are indicated on the plans. Aerial cables shall have a minimum vertical clearance of 5.5 m (18 ft).

260

807.09 Lighting Handholes. Handholes shall not be placed in areas subject to flowing or ponding water. Handholes shall be installed with the top flush with adjoining surfaces. Precast handholes with integral bottoms will be considered acceptable.

Multiple compression fittings and insulating links installed in handholes shall be taped and waterproofed by application of an approved waterproofing device. The insulation around the area to be waterproofed shall be cleaned before applying the waterproofing device. These waterproofing devices shall be designed for insulating multi-conductor cables with a minimum voltage carrying capacity of 600 volts.

270

Heavy weave fiberglass reinforced polymer concrete service boxes will be permitted as an acceptable substitute for a street and alley handhole providing that they can be placed at a location which meets both of the following conditions:

(a) there is no evidence of vehicles traveling over the area where the handhole is to be located; and

(b) it is located a minimum of 4.6 m (15 ft) from the edge of pavement, unless it is protected guardrail, unmountable curb, a structure, or an untraversable ditch.

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The handhole shall be backfilled with sand or earth containing no particles that would be retained on a 6.3 mm (1/4 in.) sieve. The backfill shall be placed as shown on the detail sheet of the plans. No additional payment will be allowed for this backfill.

807.10 Concrete Foundations For Lighting Standards. Foundations shall be class A concrete in accordance with 702. Footings may be either round or square in shape as shown on the plans.

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Anchor bolt circle dimensions shall be furnished and the anchor bolts shall be in accordance with 913.11(a)7. A rigid template shall be used to center the anchor bolts in the foundation. Unless otherwise specified, the template shall be oriented so that the mast arm of the lighting standard is perpendicular to the center line of the roadway.

Each foundation installation shall have provisions for grounding the lighting standard in accordance with 807.12. The tops of the concrete foundations shall be constructed level and only shims used to rake the lighting standard will be permitted.

Shims will not be permitted with break-away couplings. Each foundation shall have an imprinted arrow or arrows on the top of the foundation to indicate the direction of the cable duct run.

Foundations for high mast towers shall be constructed prior to constructing foundations for conventional roadway lighting.

(a) Cast-in-Place Foundations. If the sidewalls of the excavated areas remain firm and stable, concrete may be poured directly against the dirt below the level of the top 150 mm (6 in.) form. Otherwise, the concrete foundation shall be fully formed by means of a paper preformed liner or other approved means. However, the foundation shall be formed to the proper size for the top 150 mm (6 in.) before concrete is poured. If a paper liner is used, it may be withdrawn as the concrete is placed or it may be left in place permanently. If the liner is left in place, all voids between the excavation walls and the form shall be filled and compacted using size No. 53 aggregate. If the liner is withdrawn, the top 300 mm (12 in.) of the foundation shall remain formed until the concrete has obtained initial set.

(b) Precast Foundations. Precast foundations shall be complete with reinforcing bars, tie bars, anchor bolts, and entry sleeves located to provide a level mounting for the lighting standard after installation. The grounding coil, as shown on the plans, may be used for grounding lighting standards set on precast foundations. Foundation backfill shall consist of compacted size No. 53 aggregate.

(c) Grading of Foundations. Foundation projection above the finished grade shall be as shown on the plans. The excavated material may be used for this grading if it is not granular in nature and will readily stabilize and support the growth of sod. If the excavated material is unsuitable, it shall be properly disposed of and approved materials used. The area shall be sodded. Sodding will be in accordance with 621.

807.11 Placing Lighting Standards.

(a) Lighting Standards Under 24 m (80 ft) in Height. The lighting standard assembly shall consist of a metal pole, a shoe base, a frangible breakaway base or coupling where shown on the plans, and a metal mast arm for attaching the luminaire. The unit shall be assembled on the ground. Pole circuit wiring shall be installed and the luminaire shall be attached prior to erection. The factory finish of the pole assembly shall be protected from marks, blemishes, scratches, or other damage. Slings and chokers for lifting purposes shall be of nylon or other approved material. Chains, metal rope, or other abrasive materials will not be permitted for lifting devices. If damage to the factory finish occurs, repair or replacement shall be as directed.

After erection and attachment to the foundation, the pole assembly shall be plumb. The luminaires shall be level in both horizontal areas. Shims will not be permitted with breakaway couplings. Shimming will be permitted on other types of installations to rake the pole assembly to obtain the desired attitude of the luminaire where the combined weight of the pole and mast arm requires it and the luminaire saddle will not permit the adjustment. The mast arm shall be perpendicular to the axis of roadway travel unless

special orientation is noted on the plans. Unless otherwise specified, the lighting system shall consist of metal pole supports for the luminaires with an underground electrical supply system.

350 (b) **High Mast Lighting Standards of 24 m (80 ft) Height and Over.** High mast light pole sections shall be mechanically fitted in the field using factory supplied hydraulic jack or hoist puller that shall produce a minimum force of 44.5 kN (10,000 lb) per side. Field assembly procedures and assembly apparatus requirements shall be submitted for approval. Field welds will not be permitted except where shipping limitations prevent permanent factory assembly. Prior approval for field welds is required.

The pole shall be erected on the lower set of the anchor bolt nuts and secured with the top nuts. The adjustments to plumb the pole shall be made prior to the final tightening of the top nuts.

360 The pole shall be plumbed under no wind conditions before sun-up, after sun-down, or on an overcast day. The deviation from vertical shall not exceed 6.5 mm (1/4 in.) within any 3 m (10 ft) of height.

When installing the high mast power cable, one end of the power cable shall be securely connected to the luminaire ring. The other end of the power cable shall be secured to the support and terminated 0.9 m (3 ft) below this support with a heavy duty three wire electrical plug. Adjustments of the three support cable lengths shall be made prior to lowering the ring for the first time. After the support cables have been adjusted and the luminaires installed on the ring, at least one complete cycle operation of the ring shall be
370 conducted on each structure.

807.12 Grounding. Ground wire shall be No. 6 solid bare copper. Ground rods shall be 13 mm (1/2 in.) diameter by 2.4 m (8 ft) long copper-weld ground electrodes except where larger sizes are specified. The top of the ground rod shall be driven at least 150 mm (6 in.) below grade. Ground rods shall not be installed within the lighting standard, sign structure, or high mast tower foundations.

380 The ground wire shall be connected to the top or side of the ground rod. The ground rod, ground wire connection shall be made by a thermo weld process. The wire and ground rod shall be free of oxidized materials, moisture, and other contaminants prior to inserting the wire and the ground rod into the properly sized mold. The welding material shall sufficiently cover and secure the conductor to the rod. The completed connection shall be nonporous.

As an acceptable substitute to this process, a mechanical ground grid connection of an approved type may be used. Tap type clamps, parallel type clamps, U-bolt flat clamps, and crossover clamps will not be accepted.

390 Luminaire standards shall be grounded by connecting the free end of the ground wire to the grounding lug in the transformer base or pole. The free end of the ground wire shall enter the pole base through the entry sleeve installed in the foundation.

The neutral conductor of the underground distribution circuit shall be connected to the ground lug in the transformer base or pole. This connection shall include a quick-disconnect type connector kit so that in the event of a pole knockdown the connection will readily break without damage to the buried conductor.

400 The breaker boxes for the sign and underpass circuits shall be grounded by connecting the free end of the ground wire to the neutral grounding terminal in the breaker box and connecting this terminal to a grounding lug securely fastened to the metal interior of the breaker box. The conduit terminating in the breaker box and the sign or underpass luminaire housing shall have a good, clean, tight connection and act as a grounding conductor for these luminaires. The neutral conductors of the feed and distribution circuits for underpass and sign illumination shall be connected to the neutral grounding terminal in the switch box or breaker box. The neutral conductor of the distribution circuit for underpass and sign illumination shall be grounded in each luminaire by connecting a jumper from the neutral terminal of the luminaire to a ground lug fastened to the metal housing of the luminaire.

410 Sign structures shall be grounded at one sign column by connecting the free end of the grounding wire at that column to the grounding lug in the column base.

A type I service for supply of electrical energy shall consist of a conduit riser to a weatherhead. This conduit shall be grounded at the lower end by means of a standard strap grounding connection to the ground wire and ground rod. A type II service shall consist of a multiple number of conduits from underground to the bottom of the service cabinet and a single conduit to a weatherhead from the top of the service cabinet. All of these conduits shall be connected by a single ground wire from the grounding terminal to a grounding bushing for each conduit within the interior of the service cabinet. In addition a ground wire
420 from the grounding terminal of the service cabinet shall be connected through a conduit to a ground rod.

Bridge railing conduits shall be grounded at each end of the bridge railing by means of a standard grounding strap connected to a ground wire and ground rod. The ends of the conduits terminating in a bridge anchor location shall provide ground continuity by means of a grounding bushing on each conduit end and the connection of the bushing to a ground wire.

430 All equipment used in the highway lighting system shall be grounded. If necessary, additional grounding shall be installed as directed.

807.13 Luminaire Installation. Luminaire installation shall consist of the physical placing of the luminaire. Each installation shall include the furnishing and placing of the lamp as designated.

(a) **Roadway Luminaires.** Each luminaire shall be leveled in both directions in the horizontal plane after the light standard has been erected and adjusted. Rotary adjustment of the mast arm and vertical adjustment of roadway luminaires to obtain an installed level position in both directions shall be accomplished by means of the bolted
440 saddle arrangement used to attach the luminaires to the mast arm. Lamp socket positions

may be shown on the plans by type of Illuminating Engineering Society of North American (IES) light pattern. The specified lamp socket position shall be used to obtain the desired light pattern delivery. Proper connections shall be made to provide ballast operation at the voltage being supplied. Replacements needed because of faulty or incorrect voltage connections shall be made with no additional payment.

450 **(b) Sign Luminaires.** Connections in which plain and galvanized steel are in contact shall be protected such that aluminum surfaces shall receive one coat of zinc chromate primer. Steel surfaces shall receive one coat of inorganic zinc primer followed by one coat of aluminum paint. All paint shall be permitted to dry before assembly. Conduit fittings, if required, shall be watertight. Required conduit shall be either rigid or flexible as necessary. Conduit shall not be clamped to a sign panel.

460 Sign luminaires shall be mounted on overhead sign structures on two metal channels located at the extremity of the sign walkway support brackets. The distance between lighting unit support channels shall be 180 mm (7 in.). These channels shall be located in such a manner that they readily receive the mounting bolts from the rear of the sign luminaire. The installation of the sign luminaire shall consist of the physical placement of the luminaire on the channels.

470 Sign luminaires shall be connected to a phase conductor and a neutral conductor. The luminaires shall be alternately connected to opposite phase conductors to balance the load. The connections in the base of the sign structure shall be in accordance with 807.06. Conductor splicing shall be in junction boxes, in-ground handholes, inside handholes of sign structures, and circuit breaker enclosures.

470 **(c) Underpass Luminaires.** Underpass luminaires shall be mounted on the vertical side surfaces of bridge bent structures or suspended by means of pendants supported by angle-iron struts or clips fastened to the structural beam members of the bridge. All parts of the pendent pipe assembly shall be hot-dipped galvanized after threads are cut. Silicone caulking compound shall be applied to the threads during assembly of the pendent. Underpass luminaires may require separately mounted ballasts which shall be installed in close proximity to the luminaires.

Underpass luminaires shall be connected to a phase conductor and a neutral conductor. The luminaires shall be alternately connected to opposite phase conductors to balance the load. Conductor splicing will only be allowed in junction boxes, in ground handholes, and circuit breaker enclosures.

480 **(d) High Mast Luminaires.** The aiming of the luminaires shall be as shown on the plans. When the aiming process is being done the luminaire shall be oriented to conform to its raised position and the ring properly tethered to prevent rotation during the aiming adjustment. The long axis of the luminaire shall be parallel to the aiming direction indicated on the plans.

807.14 Sign, Underpass, Roadway, and High Mast Lighting Location Identification. All high mast towers, roadway light standards, underpass lighting installations, and sign lighting installations shall have an identification code number as shown on the plans. In addition, each luminaire at a sign or underpass installation shall be individually identified with a single capital letter.

The code number shall be displayed on the light standard, sign structure column, and high mast tower as shown on the plans. The underpass code number shall be displayed near the breaker box at a location as directed.

The code number for the lighting standard and sign structure column shall be applied to the pole, as specified by the manufacturer, by using individual, pressure sensitive, adhesive backed tags. The code number for the high mast tower shall be applied to an aluminum plate which is mounted with spacers away from the structure as shown on the plans.

807.15 Service Point Power Entry. The utility's requirements for service locations shall be coordinated. Unless otherwise specified, a pole shall be furnished for the service point. If the utility requires metering of the lighting system, a meter socket shall be obtained from and installed in accordance with the requirements of the utility. Grounding shall be in accordance with 807.11 and shall be a part of the service installation.

Energy shall be provided with 120/240 V service or 240/480 V service with the proper KW capacity on poles located immediately inside the right-of-way at locations designated on the plans. Electrical materials incorporated in the work shall be compatible with the service voltages supplied by the local utility.

The service voltages supplied by the local utility shall be checked for compliance with the planned voltages. If a discrepancy exists, it will be resolved as directed before work is started or any electrical equipment is purchased.

(a) Types of Service Points. Service point installations shall be of two types as shown on the plans.

1. Type I Service Point. This service point installation shall consist of class 5 wood pole, 70 mm (2 3/4 in.) galvanized steel conduits, weatherhead, photo cell and multiple relay switch. The conduit riser shall be fastened and supported on the pole by means of galvanized hook pipe straps and secured to the pole by means of a galvanized lag screw all of the proper size for the conduit being installed. Cable-duct shall be installed in the conduit riser in accordance with 807.07. The conductors shall extend beyond the weatherhead a minimum of 1.2 m (4 ft). The conductors outside of the weatherhead shall be ringed to prevent moisture from entering the conduit enclosure.

2. Type II Service Point. This service point installation shall consist of a service cabinet with a single galvanized steel or aluminum conduit riser to the weatherhead. A multiple number of galvanized steel conduits shall extend from the bottom of the service cabinet in accordance with 807.05. Underground cable-duct shall be

installed in accordance with 807.07(c). Connections, connectors, and fixtures shall be as shown on the plans.

The service cabinet shall be secured to the pole by means of a galvanized steel channel post or other approved device.

540 **(b) Sign and Underpass Circuits.** The illumination circuits for sign structures with an overhead power supply shall be protected by circuit breakers mounted on the end support.

Circuits for adjustable end support sign structures, bridge bracket signs, or underpasses shall be protected by circuit breakers mounted on the bridge or sign structure and connected to the underground distribution circuit in a handhole.

550 Circuits for sign structures with an underground power supply shall be protected by fuse connector kits in the base of the sign support. The fuse connector kits shall include bayonet disconnect features for the "neutral" side and "hot" side.

(c) Multiple Relay Switches. Unless otherwise specified, wood pole, multiple relay switches, service cabinet, photocells, photocell receptacles, weatherhead, conduit, and other miscellaneous items shall be furnished and installed as a part of the service point.

807.16 Testing of Highway Lighting System.

560 **(a) Testing Lighting Circuitry.** All necessary equipment and apparatus properly calibrated for testing the lighting circuits shall be furnished. The supplying utility shall be given advance notice of the test scheduling so their representative may witness the testing procedures if desired. Each main lighting circuit, including its branches, shall be tested for insulation resistance and continuity after it is completely installed but before the pole circuits, underpass circuits, sign circuits, and grounding circuits are connected. The insulation resistance test shall be made with a megohm meter and the resistance to ground shall be no less than 50 megohms in all lighting circuit power cables. The meter shall be set for the voltage rating of the insulation. The continuity test shall be made with an ohmmeter properly scaled for measuring the resistance of the power cables. This test shall verify the following:

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1. That each power cable is continuous to its termination points.
 2. That the cable coding at junction and termination points is consistent with cable coding at the supply point.
 3. That power cables are not crossed with the neutral or each other.
 4. That the main circuit through each of its branches does not have unusual resistance values.

580 The entire completed installation shall be tested by circuit or by such portions as may be selected and at night if directed. Tests shall demonstrate the following:

1. That all power, lighting, and control circuits are continuous, free from short circuits, and free from unspecified grounds.
2. That all circuits are properly connected in accordance with applicable wiring diagrams.
3. That all circuits are operable which shall be demonstrated by continuous operation of each lighting circuit for at least 1 h.
- 590 4. That voltage at the ends of each lighting circuit and at inter points is within allowable limits. A maximum of 10% voltage drop will be permitted for each complete circuit.

(b) **Testing and Inspecting Luminaires.** The lighting system from the service point through the last luminaire shall be subjected to 14 days of normal operation prior to final acceptance. This testing procedure may be conducted separately on each circuit or on the entire system.

600 Normal operation is defined as the luminaires being on during the darkness hours and off during the daylight hours as controlled by the service point photocells and relay switches. Malfunctioning equipment shall be replaced or repaired before final inspection. The pattern of light delivered to the pavement by roadway and high mast luminaires will be inspected at night. At this inspection, the proper tools, equipment, and personnel shall be available to make all adjustments. These items shall specifically include a bucket truck capable of reaching all luminaires in the system, safety equipment, and a level to determine the proper luminaire position.

610 **807.17 Pay Item and Installation Summary Sheets.** Prior to final inspection, two sets each of shop drawings, installation summary, and pay item summary marked Final Record shall be furnished for the light standards as installed. The installation summary shall show the effective mounting height, arm length, foundation elevation, pay item, type of base, and catalog number or drawing for each light standard furnished. The pay item summary shall indicate the pay item, quantity, effective mounting height, arm length, and type of base for each type of lighting standard furnished.

620 **807.18 Method of Measurement.** Luminaire, light standard with mast arm, high mast standard, identification number, connector kit, multiple compression fitting, insulating link, foundation, handhole, service point, and cable marker will be measured by the number of units installed. Pole circuit conductor and circuit conductor in conduit will be measured by the meter (linear foot). Pole circuit conductor will be measured from the base of the lighting standard to the terminal block of the luminaire. Pole line extension will be measured in a straight line between each pole.

Conductor in bridge conduit will be measured by the meter (linear foot) from end to end of conduit or from the end of conduit to the last bridge light pole foundation entry. An allowance of 1.5 m (5 ft) will be made for each foundation entry. An allowance of 0.6 m (2 ft) will be made for each junction box.

630 Removal of existing light structure, which shall include the pole, mast arm, and foundation, will be measured by the number of units removed.

Cable-duct and conductor in underground duct or conduit will be measured by the meter (linear foot) as follows:

(a) **From the Face of the Concrete Foundation to the Center of the Handhole or Face of the Next Concrete Foundation.** An allowance of 1.5 m (5 ft) will be made for each entry at foundations. An allowance of 0.6 m (2 ft) will be made at handholes for connection purposes.

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(b) **From Lighting Standard Bases or Handholes to Switch Boxes at Underpasses.** An allowance of 1.2 m (4 ft) will be made at the switch box for electrical connections.

(c) **From End to End of the Conduit when the Cable is in Conduit under a Roadway Surface or Shoulder.** No measurement will be made of cable-duct in conduit where it is part of a service point, sign installation, or underpass lighting system.

650 **807.19 Basis of Payment.** Luminaire will be paid for at the contract unit price per each for the type and wattage specified. Service point will be paid for at the contract unit price per each for the type specified. Light pole will be paid for at the contract unit price per each for the estimated mounting height, length of mast arm, and base type specified.

Lighting foundation, concrete, with grounding will be paid for at the contract unit price per each for the size specified. If class X material is encountered during lighting foundation excavation, payment will be made for such excavation in accordance with 206. Partial payment for lighting foundation in the amount of 80% will be made if all such work is complete except for finish grading and sodding. The remaining percentage of payment will be made upon completion of the finish grading and sodding.

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Connector kit will be paid for at the contract unit price per each for fused or unfused, as specified. Multiple compression fitting and insulation link will be paid for at the contract unit price per each for waterproofed or nonwaterproofed, as specified. Cable-duct marker, high mast tower winch drive, and handhole, lighting will be paid for at the contract unit price per each. Sign, underpass, and roadway lighting location identification will be paid for at the contract unit price per each. Circuit installation will be paid for at the contract unit price per each for the type, structure number, and number of luminaires specified. Light structure, remove and portable tower lighting drive system will be paid for at the contract unit price per each.

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Wire will be paid for at the contract unit price per meter (linear foot) for the designation, copper gage, housing, and number of conductors specified. Pole circuit

cable, THWH, stranded will be paid for at the contract unit price per meter (linear foot) for the copper gage and number of conductors specified. Conduit, steel, galvanized, 50 mm diameter will be paid for at the contract unit price per meter. (Conduit, steel, galvanized, two inches diameter will be paid for at the contract unit price per linear foot).

Payment will be made under:

680	Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol)
	Metric Pay Item	Metric Pay Unit Symbol
	(English Pay Item)	English Pay Unit Symbol)
	Cable-Duct Marker	EACH
	Cable, Pole Circuit, THWH, No. ____ Copper, Stranded, ____ __/C	m (LFT)
	Circuit Installation, Str. No. ____, ____ Luminaires	EACH
	no.	
	Conduit, Steel, Galvanized, 50 mm.....	m
690	(Conduit, Steel, Galvanized, 2 in.	LFT)
	Connector Kit, Fused.....	EACH
	Connector Kit, Unfused.....	EACH
	Handhole, Lighting	EACH
	High Mast Tower Winch Drive	EACH
	Insulation Link, Nonwaterproofed	EACH
	Insulation Link, Waterproofed	EACH
	Lighting Foundation, Concrete, with Grounding, ____ mm x ____ mm x ____ mm	EACH
	(Lighting Foundation, Concrete, with Grounding, ____ in. x ____ in. x ____ in.....	EACH)
700	Light Pole, High Mast, _____ m E.M.H.	EACH
	(Light Pole, High Mast, _____ ft. E.M.H.	EACH)
	Light Pole, Roadway, _____ m E.M.H., _____ m Mast Arm, _____ Base	EACH
	(Light Pole, Roadway, _____ ft. E.M.H., _____ ft. Mast Arm, _____ Base.....	EACH)
	Light Structure, Remove.....	EACH
	Luminaire, High Mast, _____, _____ Watt	EACH
	type	
710	Luminaire, Roadway, _____, _____ Watt.....	EACH
	type	
	Multiple Compression Fitting, Nonwaterproofed	EACH
	Multiple Compression Fitting, Waterproofed	EACH
	Portable Tower Lighting Drive System	EACH
	Service Point, _____	EACH
	type	
	Sign, Underpass, and Roadway Lighting Location Identification	EACH

720 Wire, _____, No. ____ Copper,
 designation
 in _____, ____ ____/C m (LFT)
 housing

The costs of lamps, ballast, optical systems, weatherproof housings, and electrical connections shall be included in the cost of luminaire.

730 The costs of the mast arm, J-support hook for pole circuit, handhole with cover, shoe base, transformer base or frangible coupling if required, installation on the foundation with the pole circuit, and luminaire installation shall be included in the cost of light pole.

The costs of the pole; lowering system including winch assembly, power cable, and support cable; concrete pad; luminaire ring; anchor bolts and nuts; lightning rod assembly; grounding system; and all incidental materials necessary to complete the installation shall be included in the cost of light pole, high mast. The costs of excavation, concrete, sleeves for cable duct, reinforcing steel, backfill, finish grading, and sodding shall be included in the cost of lighting foundation.

740 The costs of aerial distribution service, drops to sign structures branching off from the pole line extension, weatherheads and risers required to connect the line extension to the underground electrical distribution circuit, all anchorage, guy wires, hardware, aerial cable, electrical connections, wood poles, and incidentals required to complete the pole line extension shall be included in the cost of cable, pole circuit.

The costs of snap-on covering in light pole base and waterproof covering in underground handhole shall be included in the cost of multiple compression fitting.

750 The costs of circuit breakers; breaker enclosures; conduit; flexible conduit; conduit fittings; grounding; weatherhead; aerial cable termination; and incidentals required from the last luminaire to the point of attachment by the utility, the bottom of the riser at the structure base, or the connector kits in the base of the sign supports shall be included in the cost of circuit installation.

The cost of maintaining highway illumination during the contract time shall be included in the costs of other pay items.

SECTION 808 -- PAVEMENT TRAFFIC MARKINGS

808.01 Description. This work shall consist of furnishing and installing, or removing, pavement traffic markings and snowplowable raised pavement markers in accordance with the MUTCD, these specifications and as shown on the plans. Markings shall be installed as required unless written approval is obtained from the District Traffic Engineer to make modifications at specific locations.

MATERIALS

808.02 Materials. Materials shall be in accordance with the following:

Cones	801.07
Epoxy	913.14(b)3
Glass Beads	913.09
Preformed Plastic	913.14(b)2
Snowplowable Raised Pavement Markers	913.14(d)1
Thermoplastic.....	913.14(b)1
Traffic Paint	909.05

CONSTRUCTION REQUIREMENTS

808.03 General Requirements. Permanent pavement markings shall be placed on the surface course in a standard pavement marking pattern. Center lines shall be placed on two-way two-lane roads, lane lines shall be placed on multi-lane divided roads, and both center lines and lane lines shall be placed on multi-lane undivided roads. The markings shall be of the same material as the existing pavement markings or any durable pavement marking material.

The pavement shall be cleaned of all dirt, oil, grease, excess sealing material, excess pavement marking material and all other foreign material prior to applying new pavement traffic markings. New paint pavement markings may be placed over sound existing markings of the same color. New thermoplastic, preformed plastic, or epoxy markings may be applied over sound existing markings of the same type if permitted by manufacturer's recommendations, a copy of which shall be supplied to the Engineer prior to placement; otherwise, existing markings shall be removed in accordance with 808.09 prior to placement of the new markings. Removal of pavement marking material shall be in accordance with 808.09. The pavement surface shall be dry prior to applying pavement traffic markings.

Control points required as a guide for pavement traffic markings shall be spotted with paint for the full length of the road to be marked. Control points along tangent sections shall be spaced at a maximum interval of 30 m (100 ft). Control points along curve sections shall be spaced so as to ensure the accurate location of the pavement traffic markings. The location of control points shall be approved prior to the pavement traffic marking application.

808.04 Longitudinal Markings. All longitudinal lines shall be clearly and sharply delineated, straight and true on tangent, and form a smooth curve where required. Lines shall be square at both ends, without mist, drip or spatter.

A solid line shall be continuous. A broken line shall consist of 3 m (10 ft) line segments with 9 m (30 ft) gaps.

All lines shall be gapped at intersections unless otherwise specified or directed.

The actual repainting limits for no-passing zone markings will be determined by the Engineer.

- 60 A new broken line placed over an existing broken line shall laterally match the existing broken line, and the new line segments shall not extend longitudinally more than 10% beyond either end of the existing line segments.

(a) **Center Lines.** Center lines shall be used to separate lanes of traffic moving in opposite directions. All center line markings shall be yellow in color and 100 mm (4 in.) in width. They shall be placed such that the edge of the marking, nearest to the geometric centerline of the roadway, shall be offset 100 mm (4 in.) from the geometric centerline.

- 70 The center line of a multi-lane roadway shall be marked with a double solid line. The two lines forming the double solid line shall be spaced 200 mm (8 in.) apart and shall be equally offset on opposite sides of the geometric centerline.

The center line of a 2-lane, 2-way roadway, where passing is allowed in both directions, shall be marked with a broken line.

- 80 The center line of a 2-lane, 2-way roadway, where passing is allowed in one direction only, shall be marked with a double line, consisting of a broken line and a solid line. The broken line and the solid line shall be spaced 200 mm (8 in.) apart and shall be equally offset on opposite sides of the geometric centerline. The solid line shall be offset toward the lane where passing is prohibited. The broken line shall be offset toward the lane where passing is permitted.

(b) **Lane Lines.** Lane lines shall be used to separate lanes of traffic moving in the same direction. Normal lane line markings shall be white in color and shall be 125 mm (5 in.) wide on freeways, interstates and toll roads, and 100 mm (4 in.) wide on all other roads. They shall be offset 100 mm (4 in.) to the right of longitudinal pavement joints or divisions between traffic lanes. Normal lane lines shall be marked with white broken lines. White solid lines shall be used to mark lane lines only when specified or directed.

- 90 (c) **Edge Lines.** Edge lines shall be used to outline and separate the edge of pavement from the shoulder. Edge line markings shall be 100 mm (4 in.) in width and shall be placed such that the edge of the marking nearest the edge of the pavement shall be offset 100 mm (4 in.) from the edge of the pavement except as otherwise directed. Right edge lines shall be marked with a white solid line and left edge lines shall be marked with a yellow solid line.

(d) **Barrier Lines.** Barrier lines shall be used as specified or directed. Barrier line markings shall be solid lines of the size and color specified or as directed.

- 100 **808.05 Transverse Markings.**

(a) Transverse marking lines shall be used as specified or directed to delineate channelizing lines, stop lines, crosswalk lines, and parking limit lines. The markings shall consist of all necessary lines, of the width specified or directed and shall be in accordance with the MUTCD.

110 (b) Pavement Message marking shall be used as specified or directed for railroad crossing approaches, intersection approaches, crosswalk approaches, handicap parking spaces, and other messages applied to the pavement with pavement marking material. The markings shall consist of all necessary lines, words, and symbols as specified or directed, and shall be in accordance with the MUTCD.

808.05.1 Curb Markings. Curb markings shall consist of reflectorized paint which shall cover the face and top of the curb. The existing curb and gutter area shall be cleaned of dirt, dust, oil, grease, moisture, curing compound, and unsound layers of other materials before paint is applied to the curb surface.

120 **808.06 Pavement Marking Material Application and Equipment.** All double line markings, such as a no passing zone or the center line of an undivided multi-lane roadway, shall be applied in one pass.

Stop lines and crosswalk lines for new or modernized traffic signal installations shall be durable pavement marking material. For this application, preformed plastic may be used on concrete if permitted by manufacturer's recommendations. However, for contract completion dates in winter months when conditions do not permit application of durable markings, traffic paint markings may be substituted with an appropriate unit price adjustment if approved by the Engineer.

130 (a) **Traffic Paint.**

1. Application. Standard dry and fast dry traffic paint shall be applied only when the pavement temperature is 5°C (40°F) or above. Waterborne traffic paint shall be applied only when the pavement temperature is 10°C (50°F) or above. Standard dry or fast dry traffic paint will only be permitted between October 1 and the following April 30.

The wet film thickness of the traffic paint shall be a minimum of 380 μm (15 mils). Painted lines and markings shall be immediately reflectorized by applying glass beads at a uniform minimum rate of 0.7 kg/L (6 lb/gal.) of traffic paint.

140 **2. Equipment.** Traffic paint shall be applied with a spray type machine capable of applying the traffic paint under pressure through a nozzle directly onto the pavement. The machine shall be equipped with the following: an air blast device for cleaning the pavement ahead of the painting operation; a guide pointer to keep the machine on an accurate line; at least two spray guns which can be operated individually or simultaneously; paint agitator(s); a control device to maintain uniform flow and application; an automatic device which will provide a broken line of the required length; and an automatic glass bead dispenser which is synchronized with the marking

150 application. When fast drying traffic paint or waterborne traffic paint is used, the machine shall be capable of heating the paint to application temperatures in accordance with 909.05.

A brush or small hand propelled machine, designed for that purpose, may be used if approved to apply some painted markings.

(b) **Durable Pavement Marking Material.** Durable pavement marking material consists of thermoplastic, preformed plastic, or epoxy.

1. Thermoplastic.

160 a. **Application.** Thermoplastic marking material shall be used on asphalt pavements unless otherwise specified or directed. The pavement surface shall be primed with a binder material in accordance with the manufacturer's recommendations. Thermoplastic marking shall be applied in molten form by spray, extrusion, or ribbon type extrusion airless spray when the pavement temperature is 10°C (50°F) or above. The average thickness of each 910 mm (36 in.) length of thermoplastic marking shall be no less than 2.5 mm (3/32 in.) nor more than 5 mm (3/16 in.). Immediately following the application of the thermoplastic markings, additional reflectorization shall be provided by applying glass beads to the surface of the molten material at a uniform minimum rate of 2.9 kg/10m² (6 lb/100 sq ft) of marking.

170 b. **Equipment.** The machine used for the spray application of thermoplastic markings shall consist of a kettle for melting the material and an applicator for applying the markings. All of the equipment required for preheating and applying the material shall maintain a uniform material temperature within the specified limits, without scorching, discoloring or overheating any portion of the material.

180 The machine shall be equipped with the following: an air blast device for cleaning the pavement ahead of the marking operation; a guide pointer to keep the machine on an accurate line; at least two spray guns which can be operated individually or simultaneously; agitators; a control device to maintain uniform flow and application; an automatic device which will provide a broken line of the required length; and an automatic glass bead dispenser which is synchronized with the marking application.

2. Preformed Plastic.

190 a. **Application.** The Contractor shall provide the Department with original copies of all necessary current manufacturer's installation manuals prior to beginning installation work. No installation work shall begin prior to the Department's receipt of these manuals. These manuals will become the property of the Department.

Preformed plastic shall be applied when the air temperature is a minimum of 16°C (60°F) and rising, and the pavement temperature is a minimum of 21°C (70°F). Preformed plastic shall not be applied if the ambient temperature is expected to drop to below 7°C (45°F) within 24 h after application. The pavement surface shall be primed

with a binder material in accordance with the manufacturer's recommendations. The pavement surface shall be primed prior to the placement of preformed plastic transverse markings.

200 If there is a dispute regarding installation, the manufacturer shall provide a properly trained representative to ensure that the installation is performed in accordance with the manufacturer's recommendations.

210 **b. Equipment.** The equipment for applying preformed plastic, furnished in rolls, shall be a portable hand-propelled machine capable of carrying and applying at least two rolls of 100 mm (4 in.) to 150 mm (6 in.) widths. The machine shall be equipped with a guide pointer to keep the machine on an accurate line. The machine shall also be equipped with guide rollers and a pressure roller. The pressure roller may be a separate unit. The machine shall feed the marking material from its original carton through the guide rollers and under the pressure roller onto the pavement. The pressure roller shall be a minimum of 50 mm (2 in.) wider than the width of the marking material and shall weigh a minimum of 91 kg (200 lb). The machine shall also be capable of removing the backing paper from the marking material during the application process. Preformed plastic furnished in strip, symbol, or legend form shall be applied with suitable equipment such as hand rollers.

3. Epoxy.

220 **a. Application.** Epoxy shall be used on portland cement concrete pavement unless otherwise specified or directed. This material shall be applied only when the pavement temperature is 5°C (40°F) or above. The wet film thickness of the epoxy marking material shall be a minimum of 380 μm (15 mils). Immediately following the application of the epoxy markings, additional reflectorization shall be provided by applying glass beads to the surface of the wet marking at a uniform rate of 9.8 kg/10m² (20 lb/100 sq ft) of marking.

230 **b. Equipment.** The machine used to apply the epoxy marking material shall precisely meter the two components, produce and maintain the necessary mixing head temperature within the required tolerances, all in accordance with the manufacturer's recommendations. The machine shall be equipped with a high pressure water blast device ahead of a high pressure air blast device, both as an integral part of the gun carriage, for cleaning the pavement ahead of the marking application. The machine shall also be equipped with the following: a guide pointer to keep the machine on an accurate line; at least two spray guns which can be operated individually or simultaneously; an automatic device which will provide a broken line of the required length; and automatic glass bead dispensers which is synchronized with the marking application.

240 **808.07 Marking Protection and Maintenance of Traffic.** Protection of the traveling public, of the pavement marking crews, and of the pavement markings shall be provided during the marking operation through the use of proper equipment, traffic control devices, safety devices and proper procedures. Traffic control devices shall be placed in accordance with 107.11. Flaggers shall be provided for traffic control as directed.

(a) **Vehicle Signs.** Each vehicle in the marking operation shall display the slow moving vehicle emblem when operating at speeds of 40 km/h (25 mph) or less. The slow moving emblems shall be removed when the vehicles are operating at speeds greater than 40 km/h (25 mph). The paint crew signs shall be 600 mm (24 in.) high by 2400 mm (96 in.) wide, with 300 mm (12 in.) series C black letters on an orange encapsulated lens reflective background. Type A and C flashing arrow signs shall be in accordance with 913.13.

250 (b) **Vehicle Warning Lights.** All amber flashing warning lights and amber strobe lights mounted on vehicles used in the marking operation shall be in accordance with 801.06. All vehicles used in the marking operation shall have a minimum of one flashing amber warning light or amber strobe light which is visible in all directions.

(c) **Cones.** Cones shall be used to protect marking material which requires more than 60 s drying time. Cones shall remain in place until the marking material is dry or firm enough not to track or deform under traffic. Cones shall be removed as soon as possible and shall never be left in place overnight. Edge lines shall not require protection with cones.

260

The maximum spacing of cones shall be as follows:

	40 MPH or less	over 40 MPH
Broken Lines	every line segment	every 5th line segment
Solid Lines	6 m to 9 m (20 ft to 30 ft)	

(d) **Front Escort Vehicles.** A front escort vehicle shall be used if the marking vehicle extends across the center line while operating. This front escort vehicle shall be equipped with a forward facing paint crew sign, a rear facing slow moving vehicle emblem, and a red flag mounted at least 3 m (10 ft) above the pavement.

270 (e) **Marking Application Vehicles.** Marking application vehicles such as edgeliner or centerliner trucks shall have a rear facing type A or type C flashing arrow sign, an amber flashing warning light mounted near the center of the truck bed and an amber strobe light mounted on each rear corner of the truck bed. The amber flashing warning light and the amber strobe lights shall be mounted on retractable supports and shall be operated at a height of 3.7 m (12 ft) above the pavement unless otherwise directed.

280 (f) **Rear Escort Vehicles.** If cones are not required, rear escort vehicle shall follow a marking application vehicle at a distance of 30 to 150 m (100 to 500 ft). If an additional rear escort vehicle is required due to drying time or heavy traffic volume, it shall follow the first rear escort vehicle at a maximum distance of 300 m (1,000 ft), and may operate in the travel lane or on the paved shoulder.

If cones are required, the cone setting truck shall follow the marking application vehicle and shall be followed by a rear escort vehicle. The cone pick up truck shall be followed by another rear escort vehicle.

290 All rear escort vehicles shall be equipped with a rear facing type C flashing arrow sign mounted above a rear facing paint crew sign. On two-lane two-way roads, this type C flashing arrow sign shall be operated with the arrowhead turned off. The supply truck may be used as a rear escort vehicle providing it is empty and is equipped with the required traffic control devices.

808.08 Warranty for Durable Pavement Marking Material. Durable pavement marking material shall be warranted against failure resulting from material defects or method of application. The material shall be warranted to retain its color, reflectivity, adherence to the pavement and shall be free of other obvious defects or failures.

All pavement traffic markings which have failed to meet the warranted conditions shall be replaced with no additional payment.

300 For the terms of the warranty a unit shall be defined as a 305 m (1,000 ft) section of line of specified width in any combination or pattern.

The warranty period shall be 180 days beginning with the last working day for the total contract as defined in the final acceptance letter, but not prior to November 1 of the calendar year in which the last pavement markings were installed. If more than 3% of a unit or 3% of the total of any one intersection or set of transverse markings fails, the failed portion shall be replaced. All pavement markings required to be replaced under the terms of this warranty shall be replaced within 60 days of the notification of failure.

310 On Federal aid contracts, the 180 day warranty shall apply only to thermoplastic pavement marking material.

808.09 Removal of Pavement Markings. Pavement markings which conflict with revised traffic patterns and may confuse motorists shall be removed immediately before, or immediately following, any change in traffic patterns as directed or approved.

320 Removal of pavement markings shall be to the fullest extent possible without materially damaging the pavement surface. Pavement marking removal methods shall be sandblasting, steel shot blasting, waterblasting, grinding or other approved mechanical means. Grooving will not be permitted. Grinding will only be permitted when removing thermoplastic or epoxy pavement markings. Painting over existing pavement markings to obliterate them will not be permitted.

When a blast method is used to remove pavement markings, the residue, including sand, dust and marking material, shall be vacuumed concurrently with the blasting operation or removed by other approved methods. Accumulation of sand, dust or other residual material, which might interfere with drainage or constitute a traffic hazard, will not be permitted.

330 All damage to the pavement caused by pavement marking removal shall be repaired by approved methods with no additional payment.

808.10 Snowplowable Raised Pavement Markers. Snowplowable raised pavement markers shall be used as supplemental delineation at the locations shown on the plans or as directed.

340 (a) **Surface Preparation.** The pavement or bridge deck surface shall be cleaned of dirt, dust, oil, grease, moisture, curing compound, and loose or unsound layers of all materials which would interfere with the proper bonding of the marker to the pavement or bridge deck.

(b) **Location.** Marker locations shall be accurately laid out and approved prior to the installation operation. Markers shall not be located on surfaces that show visible evidence of cracking, checking, spalling or failure of underlying materials. Markers shall not be located within the intersection of a public road. Any marker location, which falls on any of the restricted areas, shall be moved a longitudinal distance not to exceed 10% of the required marker spacing. If this adjusted location still falls within a restricted area, then that marker location shall be deleted. Marker locations shall be as shown on the plans.

350 (c) **Reflector Color.** The color combinations of the reflectors shall be as shown on the plans unless otherwise directed. When replacement prismatic reflectors are specified, such reflectors shall not be ordered until the quantity and color combinations have been determined and approved.

360 (d) **Installation.** Marker installation shall be in accordance with the manufacturer's recommendations. The pavement surface temperature and the ambient temperature shall be at least 10°C (50°F). The pavement surface shall be dry at the time of marker installation. The installation slot shall be clean and dry before the adhesive is applied. The slot shall be filled with sufficient adhesive to provide a water tight seal between the marker base and the pavement, and to fill all voids between the marker base and the surfaces of the slot. The marker shall be placed in the slot so that the tips of the snowplow deflecting surfaces are below the pavement surface.

If the pavement surface is newly placed HMA, the pavement shall be allowed to cure for two days prior to installing the markers.

Installation of markers on new concrete pavement or bridge decks or on newly overlaid bridge decks shall not be done until after the pavement or bridge deck is ready to be opened to traffic as specified elsewhere herein.

370 The number of slots cut in one day shall not exceed the number of markers which will be installed in that day. No slots shall be left open overnight.

(e) **Removal of Markers.** Markers designated for removal shall be as located on the plans or as otherwise specified or directed. If the pavement surface or bridge deck

surface is to be removed, the markers shall be removed prior to any surface removal operation.

380 The markers shall be removed with a jack hammer or other approved equipment. Care shall be taken so as not to damage the marker base during its removal. The area of the pavement or bridge deck disturbed by the marker removal shall not exceed 75 mm (3 in.) in depth nor 75 mm (3 in.) out from all sides of the marker base. The marker removal operation shall stop if it is determined that excessive damage is occurring to the pavement, bridge deck or marker base.

390 The resulting holes shall be filled with the appropriate patching material as described herein or as otherwise directed. Concrete pavement which is to be overlaid as part of the contract and HMA pavement shall be patched with HMA intermediate materials. Concrete pavement which is not to be overlaid as part of the contract and concrete bridge decks shall be patched with magnesium phosphate concrete patching material. Overlaid bridge decks and bridge decks which are to be overlaid as part of the contract shall be patched with patching material which is compatible with the deck overlay material. All patching material shall be placed in accordance with the appropriate specifications for the patching material.

Removed markers shall remain the property of the Department unless otherwise specified.

400 Removed snowplowable raised pavement markers shall be delivered to the District Traffic Division. The markers shall be delivered in 210 L (55 gal.) metal containers with lids which may be sealed. The metal containers shall be furnished either by the Contractor or by the District Traffic Division as specified in the contract. Approximately 50 markers shall be placed in each container. Each container shall be labeled as to how many markers it contains.

All metal containers used for delivering removed markers will remain the property of the Department when no longer required for the contract.

410 (f) **Replacement of Prismatic Reflectors.** Reflectors designated for replacement shall be as shown on the plans or as otherwise directed. Prior to placement of the new reflector, the castings shall be cleaned of all remaining butyl pad materials. All loose or foreign material shall be satisfactorily removed by sandblasting, wire brush, or other approved mechanical means. Removed reflectors shall be disposed of properly off the project site.

420 **808.11 Method of Measurement.** Broken lines, placed or removed, will be measured as 1/4 of the total distance in meters (linear feet) of the broken line pattern after excluding gaps for intersections or other openings. Solid lines will be measured as the total distance in meters (linear feet) of solid lines placed or removed. The material, type, color, or width of broken or solid lines to be removed will not be considered when measuring such lines for payment.

Transverse marking lines will be measured as the total distance in meters (linear feet) of lines placed or removed. Curb markings will be measured by the meter

(linear foot) along the front face of the curb. The "No Parking Any Time" sign will be measured in accordance with 802.10. Pavement message markings will be measured by the total number of each type placed. A railroad crossing pavement message marking shall include the two R's, the X, and the three stop lines per traffic lane. Railroad crossing pavement message markings will be measured by the total number of each marking placed. Lane indication arrow pavement message markings will be measured by the number of lane indication arrowheads placed. Removal of pavement message markings will be measured in square meters (square yards) using areas shown in the following table. The material will not be considered when measuring such markings for payment.

Pavement Message Markings Table

	<u>Description</u>	<u>Area</u>
	"Ahead"	2.6 m2 (3.1 SYS)
	Combo Arrow	2.6 m2 (3.1 SYS)
440	"Exit"	2.1 m2 (2.5 SYS)
	"Left"	2.1 m2 (2.5 SYS)
	"Only"	2.1 m2 (2.5 SYS)
	Railroad "R"	0.5 m2 (0.6 SYS)
	"Right"	2.7 m2 (3.2 SYS)
	"RXR"	6.4 m2 (7.7 SYS)
	"School"	3.3 m2 (3.9 SYS)
	"Stop"	2.2 m2 (2.6 SYS)
	Straight Arrow	1.2 m2 (1.4 SYS)
	"Turn"	2.2 m2 (2.6 SYS)
450	Turn Arrow	1.4 m2 (1.7 SYS)
	"XING"	2.1 m2 (2.5 SYS)

Snowplowable raised pavement markers will be measured by the number placed or removed. Prismatic reflectors will be measured by the number furnished and installed. Each 2-way prismatic reflector will be measured as one reflector. No measurement will be made of the adhesive or the hole patching material used in the placement or removal of snowplowable raised pavement markers.

808.12 Basis of Payment. Lines and transverse markings placed will be paid for at the contract unit price per meter (linear foot) for the material, type, color, and width specified. Curb markings will be paid for at the contract unit price per meter (linear foot) for curb painting, of the color specified. The "No Parking Any Time" sign will be paid for in accordance with 802.11. Pavement message markings placed will be paid for at the contract unit price per each, for the material and message specified. Lines and transverse markings removed will be paid for at the contract unit price per meter (linear foot). Pavement message markings removed will be paid for at the contract unit price per square meter (square yard).

Snowplowable raised pavement markers, furnished and installed, or removed will be paid for at the contract unit price per each. Prismatic reflectors will be paid for at the

contract unit price per each. Each 2-way prismatic reflector will be paid for as one reflector.

If no pay items are shown in the Schedule of Pay Items for the required permanent pavement markings, a change order will be executed.

Payment will be made under:

	Metric Pay Item (English Pay Item Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol) Metric Pay Unit Symbol (English Pay Unit Symbol)
480	Curb Painting, _____ color	m (LFT)
	Line, _____, _____, _____, _____ material type color width	mm m
	(Line, _____, _____, _____, _____ material type color width	in. LFT)
	Line, Remove.....	m (LFT)
490	Pavement Message Marking, _____, _____ material message	EACH
	Pavement Message Marking, Remove.....	m2 (SYS)
	Prismatic Reflector.....	EACH
	Snowplowable Raised Pavement Marker.....	EACH
	Snowplowable Raised Pavement Marker, Remove.....	EACH
	Transverse Marking, _____, _____, _____, _____ material type color width	mm m
	(Transverse Marking, _____, _____, _____, _____ material type color width	in. LFT)
500	Transverse Marking, Remove.....	m (LFT)

The cost of metal containers for disposal of removed snowplowable raised pavement markers, if furnished by the Contractor, shall be included in the costs of other pay items. The cost of picking up and returning such metal containers, if furnished by the District Traffic Division, shall be included in the costs of other pay items.

The cost of delivering removed and packaged snowplowable raised pavement markers to the designated location shall be included in the cost of transportation of salvageable materials.

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The cost of removal of existing prismatic reflectors shall be included in the cost of prismatic reflectors.

Glass beads, binder material for thermoplastic and preformed plastic, adhesive for snowplowable markers, patching material for snowplowable marker removal, pavement cleaning, removal of excess or loose existing pavement marking material where new pavement markings are being placed in the same locations, and all necessary incidentals shall be included in the costs of the pay items.

SECTION 800 -- TRAFFIC CONTROL DEVICES AND LIGHTING

SECTION 801 -- TRAFFIC CONTROLS FOR CONSTRUCTION AND MAINTENANCE OPERATIONS

801.01 Description

801.02 Materials

801.02.1 General Requirements

801.03 Construction Signs

801.04 Temporary Worksite Speed Limit Sign Assemblies

801.05 Detour Route Marker Assembly

10 **801.05.1 Road Closure Sign Assembly**

801.06 Vehicle Warning Lights

801.07 Barricades

(a) **Type III-A Barricade**

(b) **Permanent Type III-A Barricade**

(c) **Type III-B Barricade**

801.08 Cones, Flexible Channelizers, and Tubular Markers

801.09 Temporary HMA Divider

801.10 Drums

801.11 Temporary Illumination

20 **801.12 Construction Warning Lights**

(a) **Type A**

(b) **Type B**

(c) **Type C**

801.13 Flashing Arrow Sign

801.14 Temporary Pavement Marking

(a) **Types of Temporary Pavement Markings**

1. **Painted Lines**

2. **Temporary Pavement Marking Tape**

a. **Type I**

b. **Type II**

30 3. **Temporary Raised Pavement Marker**

4. **Buzz Strips**

(b) **Marking Method On Two-Lane Pavements**

(c) **Marking Method On Multi-Lane Pavements**

1. **Lane Line Markings**

a. **Base Course**

b. **Intermediate Course**

c. **Surface**

2. **Gore Area Markings**

40 a. **Base Course**

b. **Intermediate Course**

c. **Surface**

3. **Acceleration, Deceleration, and Ramp Area Markings**

a. **Base Course**

b. **Intermediate Course**

c. **Surface**

4. **Narrow Bridge Markings**

a. **Base Course**

b. **Intermediate Course**

50 c. **Surface**

5. **Time of Installation**

801.15 Traffic Control for Temporary Traffic Stoppage

(a) **On Multi-Lane Divided Highways**

(b) **On Non-Divided Highways**

801.16 Maintenance of Traffic for Snowplowable Marker or Reflector Installation

801.17 Method of Measurement

801.18 Basis of Payment

SECTION 802 -- GROUND MOUNTED SIGNS

802.01 Description

60 **802.02 Materials**

	802.03 Location of Signs
	802.04 Excavation
	802.05 Installing Posts and Signs
	802.06 Removal or Relocation of Signs or Support Assemblies
	802.07 Remove and Reset Roadway and Bridge Reference Signs
	802.08 Shop Drawings of Signs and Sign Structures
	802.09 Final Clean-Up
	802.10 Method of Measurement
	802.11 Basis of Payment
70	SECTION 803 -- OVERHEAD SIGN STRUCTURES
	803.01 Description
	803.02 Materials
	803.03 Shop Drawings
	803.04 Excavation
	803.05 Placing Concrete
	803.06 Erection
	(a) Under Traffic
	(b) Trusses
	(c) Monotube
80	(d) Cantilever
	(e) Bridge Brackets
	803.07 Welding Aluminum Alloys for Highway Structures
	(a) Base Metals
	(b) Welding Processes
	(c) Filler Metal
	(d) Shielding Gases
	(e) Preparation of Materials
	(f) Welding Procedure
	(g) Weld Quality
90	(h) Inspection
	(i) Corrections
	(j) Qualification of Procedures, Welders, and Welding Operators
	803.08 Removal of Overhead Signs and Sign Structures
	803.09 Final Clean-Up
	803.10 Method of Measurement
	803.11 Basis of Payment
	SECTION 804 -- DELINEATORS
	804.01 Description
	804.02 Materials
100	804.03 Delineators and Barrier Delineators
	804.04 Posts
	804.05 Flexible Delineator Posts
	804.06 Method of Measurement
	804.07 Basis of Payment
	SECTION 805 -- TRAFFIC SIGNALS
	805.01 Description
	805.02 Materials
	805.03 General Requirements
	805.04 Pole Installation
110	805.05 Placing Signal Heads
	805.06 Grounding
	805.07 Wire and Cable Installations
	805.08 Controller Cabinet, Signal Service, and Detector Housing Installation
	805.09 Loop Wire Detector Installation
	(a) Megohm Test Before Splice is Made at Detector Housing for Loop Wire
	(b) Megohm Test Before Splice is Made at Detector Housing for Lead-in Cable
	(c) Megohm Test After Splice is Completed at Cabinet
	(d) Vehicle Simulator Test

	(e) Acceptance Criteria	
120	805.10 Magnetometer and Microloop Detectors	
	805.11 Steel Conduit	
	805.12 PVC Conduit	
	805.13 Foundations	
	805.14 Final Clean-Up	
	805.15 Method of Measurement	
	805.16 Basis of Payment	
	SECTION 806 -- TEMPORARY TRAFFIC SIGNALS	
	806.01 Description	
	806.02 Materials	
130	806.03 General Requirements	
	806.04 Pole Installation	
	806.05 Signal Heads	
	806.06 Grounding	
	806.07 Wire and Cable Installations	
	806.08 Controller	
	806.09 Controller Cabinet, Signal Service, and Detector Housing Installation	
	806.10 Loop Detector Installation	
	806.11 Conduit	
	806.12 Final Clean-Up	
140	806.13 Method of Measurement	
	806.14 Basis of Payment	
	SECTION 807 -- HIGHWAY ILLUMINATION	
	807.01 Description	
	807.02 Maintenance of Highway Illumination	
	807.03 Materials	
	807.04 Excavation	
	(a) Trench Excavation	
	(b) Foundation Excavation	
	(c) Landscape Replacement	
150	807.05 Backfilling	
	807.06 Placing Conduit	
	807.07 Connections in Base of Lighting Standards	
	807.08 Placing Wire and Cable	
	(a) Underground Through Cable-duct	
	1. Cable-duct	
	2. Cable Markers	
	(b) Underground Through Conduit	
	1. Cable-duct	
	2. Cable Markers	
160	(c) In Conduit Risers	
	(d) Through Conduit in Bridge Coping	
	(e) Aerial Cable	
	807.09 Lighting Handholes	
	807.10 Concrete Foundations For Lighting Standards	
	(a) Cast-in-Place Foundations	
	(b) Precast Foundations	
	(c) Grading of Foundations	
	807.11 Placing Lighting Standards	
	(a) Lighting Standards Under 24 m (80 ft) in Height	
170	(b) High Mast Lighting Standards of 24 m (80 ft) Height and Over	
	807.12 Grounding	
	807.13 Luminaire Installation	
	(a) Roadway Luminaires	
	(b) Sign Luminaires	
	(c) Underpass Luminaires	
	(d) High Mast Luminaires	
	807.14 Sign, Underpass, Roadway, and High Mast Lighting Location Identification	

	807.15 Service Point Power Entry
180	(a) Types of Service Points
	1. Type I Service Point
	2. Type II Service Point
	(b) Sign and Underpass Circuits
	(c) Multiple Relay Switches
	807.16 Testing of Highway Lighting System
	(a) Testing Lighting Circuitry
	(b) Testing and Inspecting Luminaires
	807.17 Pay Item and Installation Summary Sheets
	807.18 Method of Measurement
190	(a) From the Face of the Concrete Foundation to the Center of the Handhole or Face of the Next Concrete Foundation
	(b) From Lighting Standard Bases or Handholes to Switch Boxes at Underpasses
	(c) From End to End of the Conduit when the Cable is in Conduit under a Roadway Surface or Shoulder
	807.19 Basis of Payment
	SECTION 808 -- PAVEMENT TRAFFIC MARKINGS
	808.01 Description
	808.02 Materials
	808.03 General Requirements
200	808.04 Longitudinal Markings
	(a) Center Lines
	(b) Lane Lines
	(c) Edge Lines
	(d) Barrier Lines
	808.05 Transverse Markings
	808.05.1 Curb Markings
	808.06 Pavement Marking Material Application and Equipment
	(a) Traffic Paint
	1. Application
	2. Equipment
210	(b) Durable Pavement Marking Material
	1. Thermoplastic
	a. Application
	b. Equipment
	2. Preformed Plastic
	a. Application
	b. Equipment
	3. Epoxy
	a. Application
	b. Equipment
220	808.07 Marking Protection and Maintenance of Traffic
	(a) Vehicle Signs
	(b) Vehicle Warning Lights
	(c) Cones
	(d) Front Escort Vehicles
	(e) Marking Application Vehicles
	(f) Rear Escort Vehicles
	808.08 Warranty for Durable Pavement Marking Material
	808.09 Removal of Pavement Markings
230	808.10 Snowplowable Raised Pavement Markers
	(a) Surface Preparation
	(b) Location
	(c) Reflector Color
	(d) Installation
	(e) Removal of Markers
	(f) Replacement of Prismatic Reflectors
	808.11 Method of Measurement

